INFORMATION TECHNOLOGIES IN THE DEVELOPMENT STRATEGIES OF ASIA

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FOREWORD

Today, the United States is in a position of undisputed economic leadership, with a technology base that is second to none. However, the emergence of a dynamic global economy and the globalization of the factors that drive economic growth have created a new competitive climate that is testing the strength and durability of that leadership position. Nowhere are the effects of the dynamic global economy more obvious than in the newly industrializing economies of Asia.

The global economy enables U.S. companies to benefit from global technical advances and alliances with foreign partners. The emergence of highly effective international competitors reconfirms that our long-term competitiveness depends on a strong commitment to sustained investment in science and technology, and an ability to rapidly transform knowledge developed around the world into new products and services.

Information Technologies in the Development Strategies of Asia examines how five newly industrializing economies—the Republic of Korea (Korea), the Republic of China (Taiwan), Singapore, Malaysia, and the People's Republic of China (China)—have helped shape the new competitive climate in Asia and throughout the world. It analyzes the strengths and weaknesses of the strategies and policies behind Asia's remarkable transformation into a significant contender in today's global information technology marketplace. It also makes clear that the impact of these development strategies and policies goes well beyond the information technology arena.

The current economic difficulties of several countries caution against overly optimistic predictions of the Asia-Pacific region's ability to exert the economic leadership it seeks. Nevertheless, with Asia's continued strong commitment to technology-led economic growth and a proven record of achievement, these difficulties are expected only to delay, not halt, Asia's economic progress.

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Introduction

With accelerating globalization of commerce and development of the Asia-Pacific region, a new competitive paradigm is emerging. Today the Internet allows even small firms to enter global niche markets; at the same time, increased global competition and rapid technological change require (1) continuous research and development (R&D) to keep products competitive, and (2) global market penetration to provide scale economies adequate to ensure low-cost products. Competing can be difficult for local or regional players, as they tend to lack resources for R&D or the economies of scale necessary to keep products and costs competitive over the long term. Among developed and developing nations, there is thus a move toward large, multifaceted companies and networks of companies that can sustain long-term global competitiveness. This trend is one hallmark of the new world economy. Often, growing such companies requires multinational corporate alliances as well as improvement of local corporate competitive capabilities.

In the developing economies of Asia, successful economic growth has come through carefully focused plans and efficiency in allocating limited resources. Along with traditional development targets such as heavy industry, petrochemicals, and transportation networks, many developing economies in Asia and elsewhere are giving priority to advanced electronics, multimedia, and telecommunications, judging them to be essential to rapid modernization and economic advancement in the "information age." Another target is biotechnology. Explosive growth in these industries worldwide and surprisingly effective challenges by newcomers in less developed countries (LDCs) to traditional leaders in the global high-technology marketplace are other hallmarks of the new world economy.

The evolution of the new global competitive paradigm suggests that the United States must more carefully assess its vision and its strategies for global cooperation and competition. It also obliges U.S. government and business leaders to improve their understanding of development patterns in other parts of the world. With nearly half of the world's population and vigorous national commitments to rapid economic development, the Asia-Pacific region requires attention as the United States formulates economic and technology policy for the twenty-first century.

The impetus for this report came from an earlier study that revealed that Japanese electronics firms were under attack at the "low-cost end" of markets by the lower costs and upgraded technologies of Asian competitors.[1] The authors undertook a second study[2] to more closely observe the national and industry electronics strategies in five newly industrializing economies (NIEs) in Asia that are shaping the new competitive paradigm: Korea, Taiwan , Singapore, Malaysia, and China, including Hong Kong. These countries have been moving rapidly to ever more sophisticated stages of economic development along a continuum of growth that encompasses three stages: those based on providing low-cost labor, those based on upgrading technology and other infrastructures, and those based on developing globally competitive businesses, as described below.[3]

Providing Low-Cost Labor

Asian LDCs have been attractive to large companies that produce labor-intensive products or services and are searching for lower labor costs. The labor costs of the LDCs have been radically lower than those of industrialized countries, and their populations have been willing to work diligently for long hours. Most of the countries covered in this study are already past the low-cost, unskilled-labor stage of development. China is still solidly in this phase, though moving beyond it.

Low-cost labor provides only a temporary incentive to cost-driven companies. As local living standards and labor costs have risen, Asian LDCs, now more appropriately called NIEs, have lost competitiveness in low-wage job markets and have been forced to move beyond this growth phase in order to maintain their development momentum. China's success in attracting low-wage jobs has added impetus to its neighbors' searches for new ways to attract capital and add value to their products and services. One interesting way that Asian NIEs have met the challenge of rising domestic wages is to act as jobs brokers between multinational companies and lower-wage providers in countries such as China, the Philippines, or Indonesia. Hong Kong, Taiwan, and Singapore have all used variations of this tactic.

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1 W.R. Boulton, ed., *Electronic Manufacturing and Packaging in Japan.* NTIS # PB95-18816 (Baltimore: Loyola College, Japan Technology Evaluation Center, 1995).

2 W.R. Boulton, and M.J. Kelly, *Electronics Manufacturing in the Pacific Rim.* NTIS #PB97-167076. (Baltimore: Loyola College, World Technology Evaluation Center, 1997).

3 These stages parallel the factor-driven, investment-driven, and innovation-driven stages of growth noted in *Korea's Strategy for Leadership in Research and Development* (Washington, DC: Department of Commerce, 1997).

Upgrading Technology and Infrastructure

As Asian NIEs have lost their low-cost labor advantage, they have focused on building up national technology bases with increasingly sophisticated industrial and domestic research infrastructures and incentives designed to attract global technological leaders and advanced research activities. Singapore has been an energetic example of this phase. Its 1991–96 five-year plan budgeted over US$3 billion to upgrade its infrastructure from that of a manufacturing center into that of an innovation hub capable of creating new and better products and services for the region and the world; included was $500 million to promote innovation within companies by covering up to 70 percent of qualifying project costs. A second thrust developed specialized skills and capabilities, land requirements, and infrastructures to attract international investors. A third thrust was labor skills training for emerging industries and wafer fabrication projects.

This move to upgrade infrastructures is only the beginning of an ongoing process of reorienting traditional economies toward technology, innovativeness, and institutional dynamism. Continuing to improve local standards of living and build long-term economic viability requires sustained technological and business expansion.

Developing Globally Competitive Businesses

With today’s rapid speed of technological change, Asian NIEs have recognized that they must not only develop a world-class technological base, but also grow world-class industries of their own. Asian companies are working hard to participate fully in the global marketplace, often using regional markets as springboards. The imperative to do so is part economics—to meet the high costs of keeping up with changing technologies and market demands—and part politics and nationalistic aspiration. In the post-World War II and Cold War eras, Japan and Korea benefited greatly from U.S. technology transfers and support while systematically building their own technological leaders. Today, well-known Japanese competitors include Sony, Matsushita, Toshiba, Hitachi, Mitsubishi, Toyota, Honda, and Nissan. Korea’s globally competitive firms include Samsung, Hyundai, Daewoo, and LG. Taiwan, Singapore, Malaysia, and most recently, China, are working to build their own world-class competitors.

Asian governments play a major role in nurturing the growth of such competitors. For example, Taiwan's government has established programs that fund the life cycle of technology development through commercialization, providing funds for basic research and "ramp-up" to full production and loans for large-scale commercial expansion. Once companies (and countries) build this kind of intellectual property, they are also able to negotiate cross-licenses with global technology leaders and form international scientific and technical exchanges, which help to ensure timely product updates and global competitiveness.

Government–industry relationships tend to change during this third phase of development. For example, as local companies become sophisticated enough to develop and commercialize proprietary products, they tend to eschew public involvement in research projects. Also, companies base future corporate growth and competitiveness on global market penetration, not on national loyalties. Korean *chaebols* and Japanese *keiretsu* are struggling with this dilemma today. On the international front, global competitiveness can mean that national leaders must consider not only the domestic economy but also other economies in the region and across the globe.

Asia's Challenge to the Developed World

What is striking to U.S. observers is the high level of commitment in Asian countries to advancing their economies as rapidly as possible through the stages of development in order to achieve global economic leadership. Korea, for example, has committed to developing a world-class technological capability and infrastructure by 2001. Singapore's goal is to attain an unrivaled living standard by 2000 and surpass the U.S. standard of living by 2010. Malaysia's official vision is to become fully developed by the year 2020. Asian national leaders hold in common a conviction that electronics, information, and communications technologies are key to the future competitiveness of their domestic economies, of their peoples' standards of living, and of their countries' abilities to fully participate in and contribute to the global economy.

With Asia's continued commitment to development and proven records of achievement, the region's economic growth is predicted to continue into the twenty-first century. The Organization for Economic Cooperation and Development (OECD) in early 1998 estimated that China's gross domestic product (GDP) would grow an average 6.8 percent through 2020 compared with an average 2.8 percent for other OECD members;

Asian countries other than China and Japan were predicted to grow at an average rate of nearly 5 percent through 2000. The growth in living standards is already evident in the number of middle-class Asians, which has already skyrocketed and is expected to reach 700 million (excluding Japan) by 2000. With this kind of growth and a total market size of 3.2 billion people expected by 2000, the Asia Pacific share of world GDP is projected to reach 30 percent at the turn of the millennium. A good deal of the growth experienced so far has resulted from success in electronics and related high-technology industries, starting with assembly and purchase of foreign technology but progressing to higher and higher levels of process competency and innovation capability.

The current fiscal difficulties of several Asian countries caution against overly optimistic predictions; nevertheless, while contributing to slowdowns and restructuring now, these difficulties are expected to only delay, not halt, Asia's economic progress. Within several years, Asian economies should be growing, partly because the currency crises of 1997 and 1998 are likely to force beneficial institutional changes. Asia's economic goals and plans to achieve them remain essentially unchanged.

The authors believe that Asia's aggressive industrial development strategies will have a profound impact on the economic development of both industrialized and industrializing regions across the globe. Asian NIEs have already proven that they can build significant positions in global markets for key electronics products, among others. The following are important questions for U.S. businesses and policymakers:

- Will ongoing Asian development strategies provide equivalent successes in the future?

- Will their aspirations and accomplishments in information-related technologies challenge the leadership of established and emerging industries that are vitally important to U.S. economic competitiveness?

Observation of Asia's development strategies is a first step to answering such questions.

This report aims to provide specific examples of the development strategies being undertaken by countries in the Asia-Pacific region, especially Korea, Taiwan, China, Singapore, and Malaysia, in order to provide some insight into the long-term competitive challenges and cooperative opportunities in this part of the world. In writing this report and the two studies mentioned earlier, the authors conducted extensive research of current literature, visited numerous Asian electronics facilities, and interviewed a variety of government officials and business executives in Asia and the United States.

Examples cited in this report emphasize electronics and information industries in the development strategies of Pacific Rim countries; however, this should not suggest that Asia is ignoring the development of other growth industries such as aerospace, automobiles, biotechnology, petrochemicals, and pollution control. Also, examples given here underscore the similarity of development strategies used by the Asian countries, but there are distinct differences in national style and emphasis.

Whether the Asia-Pacific region does exert the leadership it seeks remains to be seen. It seems inevitable, however, that the area will play a significant role in the future global economy. At least in the foreseeable future, this role is likely to be based to a significant degree on electronics and information technologies.

Asian Development Patterns

Providing Low-Cost Labor

The first phase of an emerging country's economic growth is typically based on providing low-cost labor to developed countries. Asian LDCs have in this way provided international companies with the opportunity to cut the costs of labor-intensive products, which has particularly appealed to the highly competitive electronics industry. Many electronics companies from the United States, Europe, and Japan relocated their labor-intensive electronics assembly operations to the LDCs of Asia starting in the late 1960s. Korea, Taiwan, Hong Kong, Singapore, and Malaysia were early beneficiaries of such labor strategies. For example, in the late 1960s, Sylvania moved low-end stereo production to Hong Kong and Singapore; in the 1970s, Intel and Motorola set up low-cost semiconductor assembly facilities in Malaysia; in the 1980s, Philips began production of color TVs in Taiwan, and Apple began producing its computers in Singapore. Most major electronics companies have multiple operations in Asia, and most of them already have operations in China.

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On the basis of the success and rapid expansion of their labor-intensive industries, in the past 20 to 30 years Korea, Taiwan, Hong Kong, Singapore, and Malaysia have all experienced significant increases in wages, living standards, and numbers of citizens who can be termed "middle class." Their successes in turn have made them less competitive in the low-cost labor market. Today, many of the companies formerly involved in labor-intensive activities in these countries are moving these operations to LDCs such as Indonesia, Thailand, Vietnam, and the Philippines to keep labor costs competitive and to gain access to new markets and revenues.

China has been the biggest beneficiary of this migration of lower-wage jobs within Asia. By June 1996, China had registered some 280,000 foreign firms with paid-in capital of approximately $155 billion that provided 17 million jobs. In 1997, some factory wages for computer assembly in China were as low as $65 a month for 72-hour work weeks.

Korea and Taiwan have located business subsidiaries in China or the countries of Southeast Asia; Hong Kong and Singapore have made a business of assisting foreign enterprises to set up new low-cost labor arrangements in neighboring LDCs. Thus, while their own abilities to

Korea's chaebols capitalized on the country's low wages to mass-produce competitively priced light industrial and consumer exports.

offer low-cost labor have declined, Asian NIEs are still involved in the low-cost labor market in ways that are attractive to Western companies. Table 1 shows comparative statistics. Summarized below are some of the means by which Asian NIEs have taken and are continuing to take advantage of low-cost labor to improve their economic status.

Korea: Building the Strength of the Chaebols

Korea is unique among the countries discussed in this report in that early on, several of its own industrial companies were the biggest corporate beneficiaries of the country's plentiful, inexpensive labor. Taking advantage of government-subsidized loans and tax breaks, Korea's *chaebols* (vertically integrated, family-owned industrial conglomerates) capitalized on the country's low wages (and licensing of foreign technologies, etc.) to mass-produce competitively priced light industrial and consumer exports; as a result, both the *chaebols* and the Korean economy grew very rapidly. Within the past decade or so, Korea's main *chaebols* have moved beyond their own labor markets to establish electronics and other assembly facilities in Hong Kong and China, Malaysia, Vietnam, and other parts of the world—not only to take advantage of cheaper labor and new market access, but also to establish a global presence.

Taiwan: Importing Labor and Investing Overseas

Following extraordinary successes in manufacturing and assembly endeavors, rising wages in Taiwan began to threaten the competitiveness of its electronics and other products. The government passed a law allowing firms to bring in workers from outside the country for up to two years, and by 1996, nearly 25 percent of Taiwan's manufacturing workforce was foreign. The majority of foreign laborers came from the Philippines, which offered a well-educated, hard-working, English-speaking workforce. In addition, Taiwanese firms began transferring labor-intensive production to such countries as the Philippines and China. Since so many of Taiwan's foreign workers came from the Philippines, building facilities in that country was ideal; the facilities could then hire repatriated workers who had already worked two years in Taiwanese factories.

Even though many Taiwanese firms have been eager to locate operations in China, government authorities have encouraged firms to balance political risks by investing elsewhere as well. The uncertainty created by the transfer of Hong Kong to China on July 1, 1997, caused the Taiwanese government to prohibit large-scale infrastructure investments in mainland China for dams, power plants, airports, roads, and ports. Such projects are typically capital-intensive and subject to political intervention. Electronics

Table 1. Comparative Statistics of Some Pacific Rim Countries

	USA	Japan	Korea	Taiwan	Hong Kong	Malaysia	Singapore
Land area							
Sq. kilometers	9,363,130	369,700	98,445	35,990	1,065	328,550	616
Sq. miles	3,614,170	142,705	38,000	13,890	410	126,820	238
1998 Population (millions)	270.5	125.5	46.6	21.8	6.7	22.2	3.9
1998 GDP (US$ billions)	$8,508.9	$3,786.2	$301.6	$261.4	$162.3	$71.3	$84.4
1998 GDP / capita (US$) $31,451	$30,164	$6,494	$11,991	$18,584	$3,215	$21,789	
1997 R&D expenditures (US$ millions)	$206,466	$130,126	$13,522	$5,445	$403	$195	$1,417
1997 R&D expenditures by business (US$ millions)	$153,691	$92,466	$9,899	$3,345	$32	$142	$885
1998 labor force (millions)	139.86	68.37	21.57	9.46	3.38	9.01	1.93
% of labor force in population	51.69%	54.47%	46.45%	43.37%	52.02%	40.60%	49.87%
# of BS & MS degrees in NS&E	253,265	169,973	78,483	122,249	2,176	N / A	3,113
% in labor force	0.196%	0.26%	0.386%	0.135%	0.076%		0.184%
# of doctoral degrees in NS&E	18,251	10,851	1,489	4,072	443	N / A	N / A
% MS & PhDs in NS&E in labor force	0.014%	0.016%	0.007%	0.045%	0.015%	N / A	N / A
GDP / BS & MS degrees (US$ millions)	$25.18	$24.7	$4.48	$2.0	$50.6	N / A	$23.13

Notes: GDP = gross domestic product; R&D = research and development; BS = bachelor of science; MS = master of science; NS&E = natural science and engineering; N / A = not available.

Source: Statistics from IMD International, *The World Competitiveness Yearbook 1999*; and Tai Ran Hsu's "A Comparative Study on Mechatronics Education and Human Resource Development in Asian Pacific Nations and USA," *1996 Trans-Pacific Workshop on Mechatronics Technology Report*, April 1997, p. 16.

and related investments are less problematic; however, the government limits investments in any mainland Chinese project to a maximum of $50 million. With its proposed free-trade area, Okinawa may soon become a beneficiary of Taiwanese investment.[4]

[4] "Taiwan to curb investments on mainland," *The Nikkei Weekly* (June 9, 1997), p. 19.

Hong Kong began responding in the late 1980s to the pressures of escalating wages, limited resources, and global competition by establishing manufacturing partnerships with Chinese companies.

Hong Kong: Partnering with China

Although its economy was once synonymous with low-cost assembly, Hong Kong began responding in the late 1980s to the pressures of escalating wages, limited resources, and global competition by establishing manufacturing partnerships with Chinese companies. Both the real and the nominal growth of Hong Kong's industrial base declined 8 to 10 percent annually between 1988 and 1991 as operations moved across the border to take advantage of cheaper labor and land costs in China's Guangdong province. The Shenzhen special economic zone there allowed Hong Kong–based companies to supply parts and materials duty-free to Chinese companies, use their factories and workers to make products, then ship finished products duty-free back to Hong Kong for re-export to world markets.[5] Between 1982 and 1994, Hong Kong's manufacturing workforce nearly halved its contribution to the GDP, from 20 percent to under 12 percent. In spite of Hong Kong's decline in manufacturing, total employment increased during this period from 2.4 to 2.9 million, and per capita GDP increased 21 percent as displaced workers continued to provide highly valued services such as product design, parts procurement, production coordination, and product marketing and shipping.

Singapore: Promoting Regional Cooperation

In 1960, Singapore's GDP was S$2.1 billion; in 1995, it was S$34.5 billion. In the same period, manufacturing's share of GDP rose from 18 percent to 27 percent, while the contribution of electronics to manufacturing output rose from under 10 percent to over 50 percent.[6] Greater economic prosperity and full employment led to rising wages; in response to this situation as well as to its limited labor, land, and natural resources, Singapore has been aggressive in moving labor-intensive operations offshore. The government encourages both domestic and foreign companies to shift production and marketing operations to neighboring countries where costs are lower while maintaining high-level management and administrative functions in Singapore.

Singapore's experience with Japanese audio equipment maker Aiwa exemplifies the country's movement away from simple, low-cost assembly work to higher-value-added phases of production. Aiwa, which by March 1997 had moved 90 percent of its production outside Japan,

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5 Satoshi Isaka, "Hong Kong keeping 'brain' functions," *The Nikkei Weekly* (May 26, 1997), p. 23.

6 Michael Pecht et al., *The Singapore and Malaysia Electronics Industries,* Boca Raton, Fla.: CRC Press, 1997).

relocated its largest Asian production facility from Singapore to Indonesia, but at the same time established its regional center for planning and research in Singapore.

Singapore links its domestic economy to regional outreach activity primarily in the form of trade “triangles” and industrial parks. Goh Chok Tong, Singapore’s first deputy prime minister, created the first economic triangle for regional development in Southeast Asia in 1989. Under the original “SIJORI” triangle plan, the Malaysian State of Johor (next to Singapore) and the Indonesian province of Riau were to provide the land and low-cost labor for industry while Singapore provided technology and capital. Results have been mixed. While Singapore did expand its low-cost labor pool, Riau has become a tourist resort, and the State of Johor is now trying to improve its economic base by attracting technology, capital, and labor-intensive business away from Singapore.

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To facilitate exporting labor-intensive operations while keeping the administrative functions of multinational companies (MNCs), Singapore has built Southeast Asia’s most complex and advanced infrastructure (airports, ports, transportation, power, telecommunications, human resources, finance, living conditions, tax system, etc.). Despite this effort, ongoing cost pressures have continued to erode Singapore’s image as an attractive business center.[7] Singapore is now helping firms develop overall low-cost strategies by building high-tech industrial parks in China, Vietnam, and India, with varying degrees of success.

Increasing the number of low-wage jobs provided the initial stimulus for Asian economic growth, but expansion in manufacturing output tended to occur primarily as a result of increasing capital input or numbers of workers. As capital inputs became less cost-effective and employment levels topped out (despite labor imports to fill shortfalls in unskilled workers), productivity rates began to level off and even decline. To ensure their continued economic competitiveness, the Asian NIEs have committed to further improving their civil and transportation infrastructures, legislative and tax structures, and educational institutions, and especially their advanced technology and research capabilities as part of long-range plans to achieve first-world economic status.

[7] Teo Poh Keng, “Singapore tops for business,” *The Nikkei Weekly* (August 18, 1997), p. 16.

The addition of technology allows industries to increase the value added to products and services and increase their contribution to society.

Upgrading Technology and Related Capabilities and Infrastructures

Most of the emerging economies of Asia have based the second phase of their economic development strategies on upgrading their technology capabilities and related infrastructures. The addition of technology allows industries to increase the value added to products and services and increase their contribution to society. While Asian NIEs are moving away from low-skill, low-cost jobs, they are simultaneously working intently to develop domestic technology capabilities, building on their earlier successes in contract labor businesses.

Three common aspects of Asia's technology-building strategy are building research and education infrastructures focused on science and technology; targeting critical advanced technologies and products for development; and attracting (and keeping) foreign technology leaders and state-of-the-art technologies. One approach practiced by all the countries covered in this study combines all three of the above: building advanced science and technology (S&T) parks.

Another common approach in this stage is modernizing and improving national education levels, especially in science and technology. Education has a historically high social value in many Asian cultures, but it is also a developmental imperative. The goals are clearly to prepare the workforces of tomorrow and to support continued economic development, although the particulars vary greatly from country to country. Korea's literacy rate is now one of the world's highest, about 95 percent, and the country is building impressive advanced research capabilities within its public and private universities (many are industry-funded), with a new emphasis on improving critical thinking and interdisciplinary cooperation to better support innovative capabilities. China's literacy rate, narrowly defined as only 4.5 years of education, still is only about 80 percent. The country is struggling with resource allocation trade-offs between educating the masses broadly or educating a more elite group to meet the country's advanced economic requirements. Malaysia is building up both basic and advanced literacy levels and also has a unique program within its "Vision 2020" plan to instill in workers a work ethic that supports greater productivity as well as to train personnel in specific high-tech skills industry requires.

Building National Research Infrastructures

Korea

Government-supported research institutes (GRIs) have been set up throughout Asia. Korea has used GRIs effectively to prime the pump for its technological developments. The Korea Institute of Science and Technology (KIST), organized in 1966, was that country's first multidisciplinary industrial research organization. It has focused on basic problems relating to technology transfer. In 1971, the Korea Advanced Institute for Science was established to provide postgraduate education in science and engineering. The Electronics and Telecommunication Research Institute, one of Korea's leading GRIs, has evolved since 1976 out of a series of research organizations associated with different government ministries and is now affiliated with the Ministry of Information and Communications. It is recognized as the top information technology research institute in Korea and is a world leader in such technologies.

Through the 1970s, various GRIs carried out high-risk research in low-profit areas and in areas where Korean universities lacked capabilities. Before Korea's fiscal crisis, the Ministry of Science and Technology, just one of the ministries supporting S&T, gave GRIs roughly $10 million of support annually. Since the mid-1990s, GRIs have struggled to respond appropriately to industry's rapidly changing needs. The rapid pace of technological change has given a competitive edge to researchers with close industry and market ties.

Through the 1970s, various GRIs carried out high-risk research in low-profit areas and in areas where Korean universities lacked capabilities.

Meanwhile, between 1982 and 1989, the number of private industrial research institutes in Korea increased from 46 to 749 because of the government's cooperative R&D program. By 1992, the number had increased to 1,435 thanks to government support and tax incentives. During the 1970s, much of the private research focused on imitating foreign products and licensing foreign technology. In the 1980s and 1990s, the focus of private research has continued to be on products, but increasingly, these products are based on proprietary technologies, not imported ones. This shift was dramatically demonstrated when Samsung announced in December 1995 its 1Gbit DRAM (dynamic random access memory) breakthrough, ahead of all competition. Information services, multimedia, computer systems, satellite communication systems, and new display technologies are among the subjects of Korea's current private R&D efforts.

Taiwan

In Taiwan, the Ministry of Economic Affairs (MOEA) and the National Science Council direct most strategic technology investments and programs. One of MOEA's best-known technology centers is the Industrial Technology Research Institute (ITRI), which has played a primary role in providing advanced technological support for a wide range of industries, about half of which are electronics related. These electronics technologies are addressed through the Electronics Research and Services Organization (ERSO) within ITRI. ERSO focuses on semiconductor integrated circuit (IC) devices, display devices, microwave components, and electronic technologies packaging. It also provides technical services to industry. ITRI's R&D function is critical in Taiwan, since many Taiwanese companies are too small to afford R&D; for this reason ITRI has concentrated its efforts on applied research and product development, particularly for key components that are medium (three to five years) and long-term projects (over five years). After product development and initiation of pilot production, ITRI terminates its direct participation. Its $260 million annual budget is about 80 percent government-funded.

Indirect Taiwanese government sponsorship of favored product development and commercialization includes initial tax holidays, 10 to 20 percent tax credits, 50 percent partial funding or loans, and up to 60 percent matching grants for training programs.

Singapore

Extensive public involvement in high-tech R&D is relatively recent in Singapore.

Extensive public involvement in high-tech R&D is relatively recent in Singapore. The National Science and Technology Board (NSTB) was established in 1991 to promote R&D activities required to enhance the electronics industry's core capabilities and to fund and coordinate R&D in universities, polytechnics, and industry, in accordance with Singapore's "E-2000" development plan. NSTB's mission is to make the city-state a center of excellence in selected fields of science and technology to enhance its competitiveness in industrial and service sectors. NSTB's five programs are (1) partnering with industry, (2) recruiting and training on R&D workforce, (3) establishing and maintaining national research institutes and centers, (4) providing an R&D infrastructure, and (5) building international alliances and cooperative agreements.

NSTB undertakes precompetitive collaborative research with industry partners and has established the following national research institutes and technology competency centers:

1. The Institute of Microelectronics supports VLSI (very large scale integration) design, failure and reliability analysis, and advanced packaging and silicon processing.

2. The Center for Wireless Communications focuses on spectrum, wireless multimedia, modulation, and transmission.

3. The Data Storage Institute concentrates on magnetic computer-assisted design, magnetic recording, mechatronics, servo controls, laser processing, and optical technologies.

4. The GINTIC Institute of Manufacturing Technology provides computer-integrated manufacturing, automation, and process development support.

5. The Center for Signal Processing supports the computer, multimedia, consumer, and communications industries.

6. The Institute of System Science emphasizes applied research in natural language processing, neural networks, fuzzy logic, and broadband networks.

7. The Information Technology Institute emphasizes information management, multimedia, and artificial intelligence.

NSTB's partnering programs include assessment of technology trends and industry needs, support of company-based research, and funding of consortia-type research.

Although Singapore's public research institutions are providing crucial support to the country's electronics and other modern industries, by far the largest amount of research expenditure in Singapore has been private. Since at least 1978, private sector R&D investment has generally equaled or exceeded the combined investment by the government, universities, and public research institutes. The overall R&D investment rate in Singapore has about tripled in the past decade.

Malaysia

Malaysia's GRIs include the Standards and Industrial Research Institute of Malaysia and the Malaysian Institute for Microelectronic Systems (MIMOS). MIMOS, started in 1985 within the prime minister's office and now a department of the Ministry of Science, Technology, and the Environment, is Malaysia's national center of excellence in microelectronics and information technology. MIMOS projects are product oriented and focused on boosting the competitive and innovative levels of the domestic electronics industry. Six research departments indicate the fields of interest: semiconductor technology, design methodology, computer technology, product development, industrial technology, and telecommunications technology. Large-scale MIMOS projects include a microelectronics center in the Kulim Hi-Tech Industrial Park and an operational microchip plant.

Targeting Technologies and Products

Korea

As Korea's private R&D activities have grown, the government has shifted its R&D activities to large-scale projects. By 1989, KIST had participated in 5,600 research projects valued at over $260 million and employing a staff of 592, including 459 in research. In 1992, the Korean government launched 11 Highly Advanced National (HAN) projects to address the development of next-generation products and technologies. These projects included development of the following:

- highly integrated semiconductors
- an integrated services digital network (ISDN)
- high-definition television (HDTV)
- new medicine and new agricultural medicines
- advanced production systems
- new advanced materials
- next-generation vehicles
- new functional biomaterials
- technology in environmental engineering
- new energy resources
- next-generation atomic reactors and verification

Product-oriented projects target future market opportunities. "Fundamental" projects develop technologies that focus on core technologies that will advance economic, social, and personal life. The HAN projects combine joint investment by the government and Korea's largest *chaebols* with interministerial cooperation and coordination. Universities, industries, and GRIs coordinate on each project. The results have been considered only moderately successful, since global competition intensifies the speed required for technology development. Aside from such government activities, Korean *chaebols* also have targeted certain technologies and markets—such as DRAMs—with great success.

Taiwan

Taiwan has targeted critical components and products to maximize the benefits of its research programs. MOEA has developed a systematic "program for the development of critical components and products." The program focuses resources of the government and the private sector on developing critical components and products, replacing imports with local suppliers, improving local capabilities, and supporting the development of emerging industries. In 1995, MOEA's program included the 48 critical components and 24 critical products listed in figure 1. Critical products included HDTV, digital audio tape recorders, electronic still cameras, a variety of computer peripherals, and automated manufacturing equipment.

Taiwan has targeted critical components and products to maximize the benefits of its research programs.

Each item was classified into one of three groups: A, B, and C. In the A group, a GRI such as ITRI is entrusted to obtain licenses or to develop the technology, or both. In the B group, MOEA provides government financial assistance to develop prototypes of the targeted component or product. In the C group, the government supports production capacity by providing such incentives as tax credits, acquisition of industrial land, government participation in the investment, favorable loans, training of professional personnel, and special duties and import regulations. In 1995, critical components in group A included fuzzy logic ICs, liquid crystal displays (LCDs), high-density static and dynamic RAM, a variety of radio frequency ICs for telecommunications, light-emitting diodes (LEDs) for displays, and charge-coupled devices for video. Most A components were also classified B and C. As A projects were completed, they moved into categories B or C: silicon wafer fabrication had only a C priority to ramp up output.

Display components. Taiwan is working hard to end its reliance on imported visual displays and related materials for high-end products, mostly from Japan. In 1995, Japanese firms provided all of the 10-inch LCD panels used in Taiwan-produced notebook personal computers (PCs); local vendors provided 90 percent of the LCD displays used in electronic dictionaries, although 90 percent of the materials used to

Figure 1. Critical Components and Products List

Critical Products

- Improved/Enhanced Definition TV*
- Digital Audio Tape Recorder
- Projection TV*
- Electronic Still Camera*
- Multifunction Clinical Analyzer*
- Ultrasonic Diagnostic and Medical Equipment*
- Engineering Workstation*
- Multi-Processor System*
- High Resolution Page Printer*
- High Performance Scanner
- Optical Disk Drive*
- Micro Disk Drive*
- Digital Mobile Phone*
- Aircraft
- IC Memory
- Digital Storage Oscillator > 100MHz
- Wire Cutting Machines
- Robots
- NC Controlled Injection Molding
- High Speed Shuttleless Loom
- Co-Generation Equipment
- Multimedia System*
- B-Carotene**
- Breathable Fabric & Product**

Critical Components

- Fuzzy IC*
- Converter*
- >25" CRT
- Si Wafer
- LCD Display*
- DAT Mechanism*
- DRAM >4M*
- SRAM >1M*
- DSP IC*
- RF IC*
- Thin Film Disk
- CCD*
- LED*
- High Resolution Laser Enginer*
- Lithium Battery*
- A/D Converter
- 32 bit CPU*
- System Software & Tools
- Thermal Print Head
- ISDN Interface IC*
- Micromotor
- Thin film disk head
- Copper sheet for lead frame**
- Broadband Communications IC**
- Laser Diode Chip**
- Micro Fiber
- Aspherical Molded Lens*
- Anti-Vibration Rubber*
- High Pressure Rubber Hose
- Build-in Main Spindle*
- Jet Engine Compressor/Turbine Blade
- Aircraft Parts
- Etching Ai Foil*
- AF Zoom Lens*
- Watch Movement
- Automobile Transmission*
- Transmission/Brake for Bicycle*
- Electronic Control for Auto*
- 4-stroke engine for auto*
- 3-Cyanopyridine
- Si-Electrical Steel Sheet
- Linear Guide
- Automatic Coin Machine
- 4-stroke Motocycle engine
- 7-Aminocyphalosporamic acid
- p-HydroPhenyl Glycine
- CNC Controller*
- Scroll Refrigerant Compressor**

*ITRI-planned or ongoing development program

**New item (1995)

produce them were imported, mostly from Japan. Japanese firms supplied 87 percent of the high-resolution cathode ray tube (CRT) monitors for computers and 30 percent of the mid-resolution monitors.

To overcome this deficit, the government has designated displays as a critical component and has supported development of next-generation display products. In 1995, two firms produced high-technology active-matrix LCDs in Taiwan, and 13 firms produced lower-quality passive matrix displays. Table 2 shows that 10-inch color passive-matrix and active-matrix LCDs have begun pilot production, and high-end active matrix LCDs over 10 inches are being developed. ICs for color filter drivers are still imported.

Taiwan has become a close follower of the United States in high-luminance LEDs, and ITRI has developed blue LEDs, which allow full-color displays to be developed with LED technology. In 1995, Taiwan firms produced 20 percent of the mid-resolution and 80 percent of the low-resolution CRT monitors for Taiwan-made computers, although 40 percent of the monitor materials had to be imported. Taiwan had already begun to mass-produce CRTs up to 21 inches, had pilot production of CRTs over 28 inches, and was developing a wide 16:9 ratio CRT for use in HD TVs.

Semiconductor components. Among the key components it has targeted, Taiwan has been successful in entering the semiconductor industry. In 1995, Taiwan had 12 firms producing ICs with total revenues of $4 billion. These firms supplied 19.1 percent of the domestic IC requirements and planned to provide 37.8 percent of domestic demand by 2000. By then, they planned to invest $16.5 billion in 20 semiconductor wafer fabrication facilities ("fabs") with a capacity of 4.8 million ICs per month. Taiwan's goal is to increase its global share of the semiconductor market from 2.5 percent in 1995 to 7.5 percent by 2000.

Taiwan has been successful in entering the semiconductor industry.

Taiwan's 12 IC firms are the result of strategic alliances and technology agreements with the world's leading semiconductor firms, as shown in figure 2. United Microelectronics Corp. (UMC) was spun off from ITRI/ERSO in 1979. It has strategic alliances and technology agreements with SGS-Thomson, Thesys, Meridian, and Microstar (MSI). The Taiwan Semiconductor Manufacturing Company (TSMC), spun-off from ITRI/

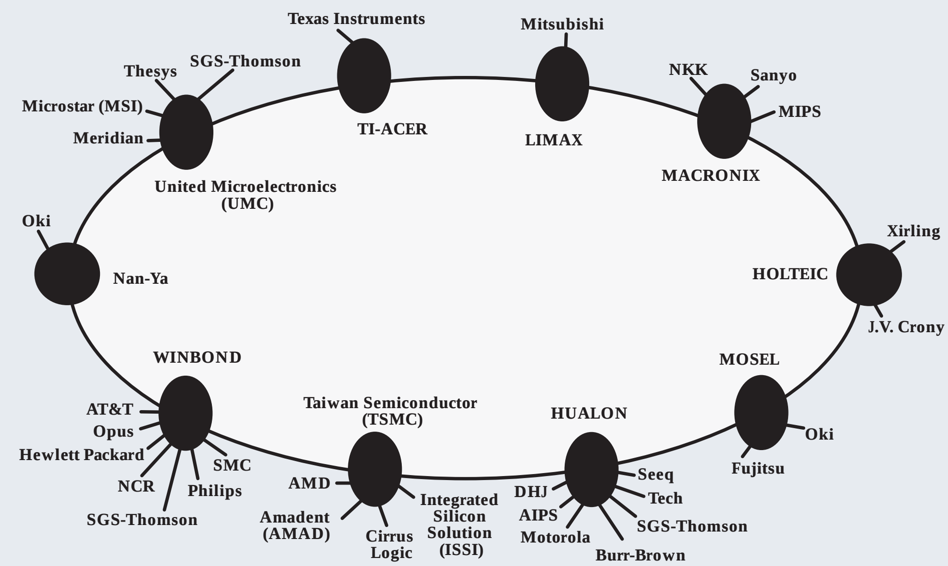
Table 2. Taiwan's Display Industry Developments

		Technology Status		
Category	**Size**	**R&D**	**Pilot Production**	**Mass Production**
CRT	14"	–	–	X
	15" FS	–	–	X
	21"	–	–	X
	>28"	–	X	–
	16:9 WST	X	–	–
LCD-STN	3-10" b/w	–	–	X
	10" color	–	X	–
LCD-TFT	<6"	–	–	X
	10" color	–	X	–
	>10" color	X	–	–

Notes: R&D = research and development; X shows what they are producing or doing themselves; shows that they are still having to import.

Source: ITRI/ERSO, 1995.

Figure 2. Strategic Alliances of Taiwan's IC Industry



Source: Market Intelligence Center (MIC) – ERSO/ITRI Industrial Technology Information Service (ITIS) Project.

ERSO in 1982, has technical and strategic alliances with Advanced Micro Devices (AMD), Cirrus Logic, Amadent (AMAD), and Integrated Silicon Solution, Inc. (ISSI). TSMC, now the second largest foundry in Asia, supplies Fujitsu, Ltd., of Japan with 16-megabit DRAMs under Fujitsu's brand name.

TSMC planned to begin producing 64M DRAM chips for Fujitsu in 1997 using Fujitsu's technology.[8] Acer has an IC joint venture with Texas Instruments. Taiwan's largest conglomerate, Nan Ya Plastics, has licensed the technology of Oki (Japan) for its new DRAM fab. In 1994, Vanguard International Semiconductor was spun off from ITRI/ERSO to produce submicron memory ICs in Taiwan. Most of the capital came from government and local banking sources. To further strengthen the IC industry's infrastructure, ERSO established the Electronics Testing Center in 1982. The first domestic mask manufacturer, Taiwan Mask Corporation, and EMMT System Corporation were spun off in 1988. In 1995, 26 companies in Taiwan were involved in IC design with total revenues of $593 million.

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8 Kaoru Morishita, "Fujitsu dips into Asian chip market," *The Nikkei Weekly* (June 23, 1997), p. 22.

Attracting Foreign Technology Leaders

The example of Taiwan's targeted investment in ICs illustrates another ingredient of successful economic development in Asia: in order to enter and compete in markets for technologically advanced components and products, Asian NIEs have relied heavily on cooperation with foreign technology leaders, often by expanding on relationships begun in contract labor arrangements. For a newly industrializing economy, overcoming the financial and technical challenges of expanding into advanced fields may be feasible only with such cooperation. For this reason, Taiwan, Singapore, and Malaysia have been strongly committed to attracting and keeping the involvement of leading companies, especially in the 1990s. Once foreign corporations have a stake in local markets, they typically continue to upgrade technologies.

U.S., Japanese, and European firms are rapidly transferring technologies into Southeast Asia, reducing the time it takes to produce next-generation products locally. For example, because Intel's customers must be able to install new microprocessors in the latest products, it produces motherboards to facilitate the introduction of its latest microprocessors. It also transfers next-generation assembly technologies to Asian customers as quickly as possible to ensure market penetration. Orient Semiconductor Company in Taiwan licensed tape carrier production technology for making daughter boards for notebook computers.

U.S., Japanese, and European firms are rapidly transferring technologies into Southeast Asia.

Table 3 summarizes the wide variety of policy mechanisms Asian governments use to attract multinational corporations, including direct R&D investments, trade policies, technology transfer, tax incentives and investment subsidies, and training and consulting services. Singapore provides a full range of programs, while Malaysia and Taiwan offer much simpler and more focused incentives. Hong Kong has taken a more passive approach.

While many Asian NIEs are working hard to attract foreign firms, there is some hesitation about inviting too much foreign involvement. Most of them have used various import controls or regulations to place some restrictions on local operations of foreign firms. China, for example, is caught between its need to protect its weak state-owned enterprises (SOEs) from foreign competition and its need to increase their access to foreign technologies. To upgrade and modernize its SOEs, China is working to provide internal support while encouraging limited partnerships with foreign firms. The majority of PC exports from China are made by joint ventures of SOEs with foreign companies.

Table 3: Industrial Development Support in Asia

	Japan	Korea	Taiwan	China	Hong Kong	Singapore	Malaysia
Government R&D	Ö	Ö	Ö	Ö	Ö	Ö	Ö
Direct R&D funding	Ö	Ö	Ö	Ö		Ö	Ö
Import controls		Ö		Ö			
Direct support for joint ventures / technology transfers				Ö	Ö	Ö	
Subsidized loans	Ö	Ö		Ö		Ö	
Tax incentives	Ö		Ö			Ö	Ö
Export promotion	Ö	Ö			Ö	Ö	Ö
Training support	Ö	Ö	Ö		Ö	Ö	Ö
Direct consulting / strategic assistance					Ö	Ö	

Note: R&D = research and development
Source: The Boston Consulting Group, *1992/1993 Techno-Economic and Market Research Study on Hong Kong's Electronics Industry*. Hong Kong Government Industry Department, August 20, 1994, p. 232.

Malaysia has historically had a strong emphasis on national self-reliance—a theme that echoes throughout Asia—but in the past 10 years has decided that in the interest of accelerating its economic growth, it is willing to postpone this goal in the short term in order to achieve world-class economic status more quickly. Therefore, Malaysia has become more open to foreign direct investments since 1990, and has offered significant incentives to foreign companies willing to invest in enterprises that facilitate technology transfer. These incentives include generous "pioneer status" investment tax exemptions and allowances, financing of up to 100 percent of some costs if technology transfer is involved, infrastructure construction, relaxation of regulations governing employment of skilled expatriates and foreign workers, and specialized training of workers.[9]

More than most other Asian countries, Singapore sees attracting MNCs as the centerpiece of its development strategy.

More than most other Asian countries, Singapore sees attracting MNCs as the centerpiece of its development strategy. Half the 4,000 MNCs located in Singapore have established regional headquarters there. Over 80 MNC offices, including Hewlett-Packard, Compaq, Motorola, Hitachi, Matsushita, Philips, Seagate, National Semiconductor, SGS-Thomson, Siemens, Murata, SCI, Sony, Thomson, Toshiba, IBM, and Texas Instru-

[9] M. Pecht, D. Beane, and A. Shukla, *The Singapore and Malaysia Electronics Industries* (Boca Raton, Fla.: CRC Press, 1997).

ments each spend over $25 million per year in local expenses. Since MNCs are the driving force behind Singapore's industrial development, the Economic Development Board (EDB) plans to provide special incentives to attract another 120 regional headquarters, each spending over $25 million per year, by 2000. Companies awarded status as operational or business headquarters benefit from incentives that include tax concessions on offshore income.[10]

Responding to liberal incentives and excellent supporting infrastructures, MNCs continue to establish advanced technology centers in Singapore. Motorola set up 120 engineers at its Asian Motorola Manufacturing Systems facility in Singapore to carry out manufacturing R&D and to transfer developments to other sites in the region. SGS-Thomson Microelectronics conducts semiconductor research on digital signal processing, BICMOS (bipolar complementary metal oxide semiconductor) silicon wafer processing, and advanced packaging technologies. Siemens Components has established an R&D IC design center, including testing, packaging, and manufacturing technologies for use in the region. In July 1997, Germany's Wacker Siltronic AG announced its plans to spend S$478.5 million (US$337 million) to build Singapore's first silicon wafer manufacturing plant, which will supply silicon wafers to wafer fabs in the Asia-Pacific region.[11] With 400 companies from northern Europe, Singapore opened the North European center of trade and industry in 1998. It will house up to 100 midsize companies from Denmark, Finland, Norway, Sweden, and Iceland. The North European center will be 90 percent financed by Singaporean companies at a cost of $69.8 million. A German center opened in 1995.

Building Advanced Technology Parks

High-profile advanced S&T parks, like special economic zones, are popular in Asia as a means of upgrading technology. They are designed to combine and concentrate the advantages of many of the kinds of strategies summarized above: (1) support R&D, commercialization, and education activities; (2) focus on key technical fields and products; and (3) promote and facilitate international financial and technical participation. They have the added advantages of bolstering national pride, fostering interdisciplinary synergies, and enhancing concentration and control of limited resources.

High-profile advanced S&T parks, like special economic zones, are popular in Asia as a means of upgrading technology.

[10] *EDBm International Business Hub 2000* (Singapore: EDB, 1995).

[11] http://www.nb-pacifica.com/headline; accessed July 29, 1997.

Countries usually offer special incentives for both foreign and domestic investment in projects within the parks that further specific national development goals. For example, China offers foreign firms reduced tax rates of 15 percent and greater incentives at start-up time for qualifying projects in its industrial parks. Firms are exempt from taxes for two years once they begin to make profits; then they are exempt from 50 percent of their taxes between years three and five. Firms that export at least 70 percent of their output are taxed at a 10 percent rate.

Singapore, having successfully established science parks of its own, is making a business of helping other countries establish and run focused high-technology parks. The China-Singapore Suzhou Industrial Park, initiated in 1995, has attracted investment commitments of $2 billion from 62 international companies. About 20 companies are already in production, among them Selectron Corp., the world's second-largest producer of motherboards, which has established a $45 million facility. The Vietnam-Singapore Industrial Park was launched in May 1996 near Ho Chi Minh City. India and Singapore established the Information Technology (IT) Park in Bangalore in September 1995 specifically to take advantage of India's 140,000 low-cost computer programmers. With stiff competition from other IT parks in India and the region, such as Malaysia's Multimedia Super Corridor (MSC), the focus of the Bangalore park was expanded in early 1997, and it was renamed the International Technology Park.

In 1980, Taiwan established its Hsinchu industrial park, now home to a large share of the island's high-tech manufacturers, including, in 1995, 51 semiconductor firms, 39 PC/peripheral firms, 30 telecommunications firms, 25 optoelectronic firms, 16 precision machinery firms, and 9 biotechnology firms; of these, 25 percent were foreign owned. The park provides one-stop permitting, five-year corporate income tax exemptions, low-interest loans, and tax credits for R&D investments, factory automation, and human resource development. Annual sales in 1994 were $6.4 billion. On the basis of the successes of the Hsinchu park, in 1997 the government opened a new science park at T'ai-nan in the south of Taiwan. Thirty-eight wafer, computer, and other factories are being built there, including plants for United Microelectronics Corp., Texas Instruments-Acer, several Japanese electronics firms, IBM, Motorola, and new 8-inch- and 12-inch-wafer plants for TSMC, Taiwan's oldest electronics company. Mosel Vitelic is spending about $3.6 billion to build a 12-inch-wafer plant there. The new park fits into Taiwan's blueprint to become a "high-tech island" and its expectation that, by 2000, 40 percent of the island's manufacturing output will be in technology-intensive industries.

Malaysia operates several industrial parks under the premise that a group of industries working in a common environment can accomplish much more than in isolation. The government strategy is to include both public and private research institutions, promote hybrid technologies, upgrade local university laboratories, establish technology centers, and fund both joint and individual R&D projects. Two well-established Malaysian industrial parks are the Technology Park of Malaysia (TPM) near Kuala Lumpur and Kulim Hi-Tech Industrial Park near Penang. TPM was started in 1988 "to be the best in providing the infrastructure, facilities, and services related to the development of knowledge-based industries."[12]

TPM's main thrust is support of industrial high-tech entrepreneurship. Over the next five years, TPM plans to focus on three broad technology fields: manufacturing and industrial engineering, information technology and multimedia, and biotechnology, emphasizing R&D, commercialization, and human resource development. As is common, general and customized financial and other incentives support foreign participation in the parks.

Developing Globally Competitive Businesses

With increasingly sophisticated technology capabilities, the third phase of an emerging country's successful economic development tends to be based on transforming local firms into first-class high-tech competitors in the global marketplace. While foreign-owned MNCs may aid in developing an economy, sustained development now requires establishing domestic industries' strength in emerging industries and technologies. Being able to upgrade imported basic technologies and develop higher value-added components and products is just the beginning. Domestic firms tend to contribute more to the local economy and are less likely to move out when costs of doing business rise. The success of local firms requires that they achieve economies of scale and size adequate to support state-of-the-art research and development of products for emerging industries. To reach adequate size, firms must expand into markets beyond their home bases, thereby competing with leading multinational firms. Like Japan, Korea has been especially successful in developing

[12] http://www.tpm.com.my; accessed May 1998.

Korea's chaebols, large conglomerates, have been the major beneficiaries of government development policies and research support.

world-class competitors. Today, Singapore has the most dynamic strategy for building its own global players.

Korea's Global Players, the Chaebols

Korea's *chaebols*, large conglomerates, have been the major beneficiaries of government development policies and research support. Samsung, Daewoo, and LG have become leaders in the global electronics industry over the past 25 years. Despite current restructuring, these family-dominated companies established after World War II continue to rank among the largest companies in the world. Korean *chaebols* accounted for 8 of the 12 largest East Asian firms and 43 of the largest 100 East Asian firms in 1995 sales, excluding Japan and China.[13] Korea's largest 8 *chaebols* are Samsung Electronics Co., Hyundai Motor Co., Korea Electric Power Corp., Pohang Iron & Steel Co., Yukong, Ltd., LG Electronics Co., Kia Motors Co., and Daewoo Heavy Industries Co. *Chaebols* produce almost 50 percent of Korea's gross national product (GNP) and account for 70 percent of the country's exports. The top 30 *chaebols* control 821 firms.

In 1995, the Samsung Group, Korea's largest *chaebol*, had sales of $87 billion, 233,000 employees, and 340 facilities in 66 countries. The group's goal is to be ranked among the world's top 10 companies by 2000. Samsung has focused on four core industries: electronics, machinery, chemicals, and finance.[14] Samsung's strategy of "globalization and localization" includes operations worldwide to access local markets. In 1995, Samsung had regional headquarters in Europe, North America, Japan, China, and Singapore. To compete globally, Samsung's strategy has been to produce the world's best products. The group invests more than 7 percent ($2 billion) of its total revenue in R&D in order to build technological leadership.

Daewoo Group revenues were $65 billion in 1996, with $13 billion in exports. Daewoo has 25 domestic companies, 277 overseas subsidiaries, and over 191,000 employees worldwide. In 1996, Daewoo ranked 34 in the *Fortune* Global 500. "Daewoo Globalization Through Daewoo Technology" is the theme of the company's Vision 2000. Daewoo had 12,000 R&D personnel in 1996 and invested $1 billion in R&D. It challenges member companies to become industry leaders by the year 2000. Goals include total group sales of $177 billion (table 4) with a worldwide network of 650 facilities in over 150 nations. This network will include

[13] "Korean companies lead sales rankings," *The Nikkei Weekly* (Dec. 15, 1997), p. 20. Research by The Nihon Keizai Shimbun, Inc.

[14] Makoto Kajiwara, "Kia Motors wins reprieve," *The Nikkei Weekly* (July 21, 1997), p. 23.

Table 4. Vision 2000: Daewoo Group Sales Goals by Division for 2000 (Total Sales of $177 billion)

Trading	$74 billion
Motor Vehicles	$30 billion
Heavy Industry & Shipbuilding	$18 billion
Electronics & Telecommunications	$28 billion
Construction & Hotels	$20 billion
Finance & Service	$7 billion

430 sales subsidiaries, 130 manufacturing subsidiaries, 20 technical and design R&D centers, and 70 local branch offices engaged in trading and related activities.

The LG Group launched Leap 2005 in March 1996 with the goal of reaching annual revenues of $385 billion by 2005. LG intends to set the global standard for quality and service in emerging business sectors such as communications, multimedia, environmental technologies, bioengineering, broadcasting media, heavy industry, energy, and infrastructure development. LG's core industries include chemicals and energy, electronics, machinery and metals, trade and services, and finance businesses.

To help meet the ambitious goals mentioned above, Korean *chaebols* make significant investments overseas as they build global competitiveness. In 1995, foreign direct investment in Korea totaled $1.9 billion. In contrast, overseas direct investment by Korean firms reached $3.1 billion as the government reduced foreign investment restrictions and simplified procedures. The top five *chaebols* plan $70 billion in overseas direct investment in the coming decade. LG Group plans to build a home electronics and semiconductor plant in the United Kingdom at a cost of $2.6 billion. Hyundai Electronics Industries Company plans to set up a $1.4 billion semiconductor plant in Britain.

Korean chaebols make significant investments overseas as they build global competitiveness.

Korean *chaebols* are also buying foreign firms to gain instant access to foreign markets and to add brand names and new technologies, as shown in table 5. Daewoo purchased France's Thomson Multimedia and acquired a majority share of Zenith to become the world's biggest producer of televisions. Samsung bought a large stake in AST Research, a California PC maker. Hyundai acquired 40 percent of Maxtor in 1993 to build a position in the disk drive business.

Table 5. Major Korean Overseas Investments

Investor	Company	Equity %	Investment ($ million)	Product
Samsung	AST	46	438	PCs
Hyundai	Maxtor	60	380	disk drives
LG	Zenith	58	350	consumer electronics
Hyundai	GIS*	100	340	chips
Daewoo	FSO	40	280	cars
Samsung	FGT	100	260	glass bulbs
Daewoo	DCM	50	190	cars
Daewoo	DAEHA	70	163	hotels
Samsung	Entel	15	147	telecommunications
Daewoo	FAW	50	137	car engines

* AT&T microelectronics product division

Source: *The Economist*, October 5, 1996, p. 104.

Although for the most part the success of the *chaebols* has until recently impeded the growth of new, smaller companies in Korea's computer market, TriGem has become one of Korea's new success stories. This midsize firm held a 22 percent share of Korea's PC market in 1996. In 1995, TriGem manufactured over 600,000 PCs and recorded revenues of over $850 million. Foreign companies had only a 7 percent share of the Korean PC market. Hewlett-Packard and IBM, the leading U.S. players in Korea, could garner only 2 percent and 1 percent of the market, respectively. The Korean government has been seeking ways to promote the growth of new businesses; TriGem's success indicates some progress on this front.

Taiwan is concentrating on electronics, its top export; already it has become the world's fifth largest supplier of PCs.

Taiwan's Global Market Position

Taiwan is concentrating on electronics, its top export; already it has become the world's fifth largest supplier of PCs. Taiwanese firms moved from assembling products such as transistor radios, TVs, and tape recorders in the 1960s, to manufacturing CRTs in the 1970s, to producing color monitors, semiconductors, electronic watches, and IBM-compatible PCs in the 1980s, becoming larger and more successful in each stage. In the 1990s, Taiwan's strategy moved it into production of the microelectronic components needed for its leading suppliers of motherboards, monitors, scanners, and computer mouse devices. Table 6 shows Taiwan's global market share in key electronics components.

Table 6. Taiwan's Top 10 Products (1995)

Product	Value ($ million)	% change 1995/94	Volume (million)	Worldwide Market Share
Monitors	7,271	38	31.3	57%
Notebook PCs	3,339	22	2.6	27
Desktop PCs	2,314	48	4.6	10
Motherboards	2,046	21	20.8	65
Power Supplies	895	22	34.3	35
Scanners	540	37	2.5	64
Graphic Cards	516	7	9.3	32
Keyboards	358	32	32.8	65
CD-ROM Drives	305	1,906	3.7	11
Network Cards	298	41	10.3	38
Others	1,785	51	N/A	N/A
Total	**$19,667**	**N/A**	**N/A**	**N/A**

Note: N/A = not applicable

Source: ITRI, 1996.

In 1995, computer monitors were a $7.2 billion business for Taiwan, which had a world market share of 57 percent. Taiwanese companies held 65 percent of the world motherboard and keyboard markets, 64 percent of the scanner market, 38 percent of network cards, 35 percent of power supplies, 32 percent of graphic cards, 27 percent of portable PCs, and 11 percent of CD-ROMs. Taiwan also held 72 percent of the world-wide computer mouse market in 1995.

Taiwan's computer-related output was valued at $19.7 billion in 1995. Information products rose from 22.8 percent to 33.8 percent of Taiwan's electronics output between 1986 and 1995. The shift into computers and related components has been highly successful, as shown in table 7. In 1995, Taiwan held 27 percent of the global notebook PC market and 10 percent of the desktop PC market. Taiwan supplies all computer components except hard disk drives. While Taiwan's share of notebook PCs was projected to exceed 38 percent in 1997, the production of desktop PCs was being moved to low-cost labor countries such as China and the Philippines. Taiwanese firms have excelled in introducing computers with the latest components.

Table 7. Taiwan's Global Market Share

	1993	1995	1997
Notebook PCs	18.2%	27.0%	38.7%
Desktop PCs	7.5%	10.0%	8.9%

Source: ITRI, 1998.

Taiwanese vendors have become original design manufacturers that sell "ready to go" products to original equipment manufacturers. While it took three years for Taiwan to introduce the first IBM-compatible 286 computer in 1985, Taiwanese firms were only two months behind in introducing the first Pentium-based systems in 1993.

By 1997, Taiwan was first to introduce the latest components and most advanced computer designs. With growing strength in product design and new product development, Taiwanese companies continue to strengthen their global market position.

The Taiwanese firms Inventec, GVC, Tatung, First International, Elite, Quanta, and Twin Head are the major suppliers to the world's top 10 PC companies, including Compaq, IBM, Apple, Packard Bell-NEC, AST, Toshiba, and Hewlett-Packard, as shown in table 8. They all aspire to stand-alone status like that of Acer, Inc., Taiwan's leading global player, which ranks as one of the five largest component makers in the world and has one of the top 10 PC brands in the world.

Singapore's Strategy for Local Enterprises

Singapore's EDB is working with over 250 local firms to help them become Asian MNCs with operations in at least three countries, with sales over $400 million, and with established brand names such as Creative Technology. EDB has identified promising local enterprises with strong core capabilities, clear vision, and high growth potential. Aztech Technology, which accounts for almost 90 percent of the world's sound card market, is one such company. Singapore's largest semiconductor foundry, Chartered Semiconductor Manufacturing (CSM), is 84 percent owned by the government and produces application-specific integrated circuits. Within the world's $6 billion semiconductor foundry market, CSM ranks second, with 5.3 percent of the market. (Taiwan Semiconductor Manufacturer Company is the leader, with about 20 percent.) Of CSM's $1 billion in revenues, about 60 percent comes from the United States, and another 30 percent comes from Taiwan. Toshiba Corporation and CSM have announced a five-year partnership to produce embedded

Singapore's EDB is working with over 250 local firms to help them become Asian MNCs with operations in at least three countries.

Table 8. Taiwan's Leading PC Vendors

Top 10 PC Firms	Taiwanese Suppliers	Notebook PCs	Desktop PCs
Compaq	Inventec	X	–
IBM	ASE	X	–
Apple	Acer	X	–
Packard Bell	Inventec	X	–
	Tatung / GVC	–	X
NEC	First Intl.	X	–
	Elite	X	–
	GVC	–	X
AST	Quanta	X	–
	AST	–	X
Dell	Quanta	X	–
Toshiba	–	–	–
Hewlett-Packard	Twin Head	X	–
Acer	Acer	X	X

Note: X shows products the company makes; – shows what products it does not make.

Source: GVC, 1997.

DRAMs for multimedia applications. This leading-edge systems-on-silicon technology was to enter the market at the end of 1998. CSM plans two additional wafer fabs, including a joint venture with Hewlett-Packard and Singapore's EDB.

Singapore's strategy is to develop 100 promising local enterprises with revenues greater than $100 million each within 10 years. These firms are growing at an average of about 30 percent annually. By 2000, EDB expects that between 50 and 70 will exceed the $100 million goal and be capable of competing in the global marketplace. EDB manages a $1 billion fund for strengthening partnerships between MNCs and local enterprises, helping the local firms go regional. EDB shares start-up costs and business risks with key investor companies by co-investing in strategic projects both in and outside Singapore. It makes equity investments in projects that support its programs and fill critical gaps in industry technologies.

Future Developments

The rapid progress of the Asian NIEs through the three stages of development is due in large measure to careful planning, continuous reevaluation, and long-range goals for product and component developments. With resources still limited, hard decisions must be made about what industries to support in order to continue planned development into the future. All the countries discussed here have detailed central plans for their development into the twenty-first century, and all of those plans include a renewed emphasis on targeting high-end electronics and information technologies, attracting multinational investment, providing a first-rate technology infrastructure, and fostering the growth of indigenous high-tech global players. The plans noted below offer a glimpse into the mind-set of Asian leaders.

Korea: Advanced Telecom and IT

Korea's national commitment to key technologies and products prominently features information technologies.

Korea's national commitment to key technologies and products prominently features information technologies, including telecommunications, information systems, and software. This country plans for this sector—6.9 percent of the national economy in 1996—to grow 19.6 percent a year to 2001 (double the average world growth) and to contribute a 10 percent share of the domestic economy by 2001. To achieve this goal, annual public and private sector investment—8.7 trillion won in 1996 (about $10.3 billion at 845 won / US$1)—is expected to almost triple by 2001.[15] As an indication of the dedication to and progress in developing this sector, Korea's number of phone subscribers increased from 3 million in 1980 to 10 million in 1988 and to 20 million as of May 1997, in a country with a population of 46 million. In 1980, 10 percent of the switching systems were electronic (TDX); in 1988, 70 percent were electronic; and in 1997, 100 percent were electronic, 65 percent digital. The government's forecast is that by 2001, subscribers to wireless telecom services (cellular and PCS) will number 13 million; the wireless market will amount to 92 percent of the wired market; and online communications services will be worth 2.8 trillion won (about $3 billion at 900 won / US$1, April 1997).

[15] http: / / www.nb-pacifica.com / headline / koreasitsectortoposta_969.html; accessed May 27, 1997.

Taiwan: Information Technology

In 1995, Taiwan's ITRI ranked Taiwan among the world leaders in electronics products (table 9). It ranked fourth in information technologies, seventh in communications products, and fifth in consumer electronics products and in electronic components such as semiconductors, optoelectronics, displays, and IC packaging. As the fourth-largest producer of ICs, Taiwan had wafer fabrication factories producing $4 billion in semiconductors in 1995, was mass producing 16M DRAMs, and planned to have 20 8-inch wafer fabs operating by 2000. Although it plans to continue to be a world leader in electronics, Taiwan is beginning to move into other areas, including information technologies. Other critical products identified for support include medical diagnostic equipment, aircraft, robots, cogeneration equipment, and breathable fabric.

Of Taiwan's electronics output, information-related electronic components increased from a 38 percent to a 53.4 percent share between 1986 and 1995, and this share is expected to grow further. Although communication electronics has so far been a small proportion of the total electronics market, Taiwan is now targeting it as a future growth business. Between 1986 and 1995, consumer electronics fell from 30.9 percent to 7.3 percent of Taiwan's electronics output, after the government decided that electronic games and toys were intellectually unhealthy for its children.

To sustain its economic development, Taiwan targeted 10 emerging industries in 1992: information, communications, consumer electronics, semiconductors, precision machinery and automation equipment, aerospace, advanced materials, specialty chemicals and pharmaceuticals, medical and health care, and pollution control and treatment industries.

Table 9. Taiwan's Global Electronics Position in 1995

Division	Global Rank	Leading Countries
Information	4	USA, Japan, Germany
Communications	7	USA, Japan, Germany, France, Italy, Britain
Consumer Electronics	5	Japan, Korea, USA, France
Electronic Components	5	Japan, USA, Korea, Germany
ICs	4	USA, Japan, Korea

Source: ITRI, 1996.

Of these, information, precision machinery, and specialty chemical industries are expected to become Taiwan's leading industries by 2002.

Malaysia: Multimedia and IT

Malaysia plans to invest more than $2 billion over the next decade to become the multimedia hub of Southeast Asia.

Malaysia plans to invest more than $2 billion over the next decade to become the multimedia hub of Southeast Asia. In August 1995, Prime Minister Mahathir proposed the Multimedia Super Corridor (MSC) project to foster IT industries. MSC stretches south of the capital of Kuala Lumpur to where a new international airport and new federal capital are under construction—a 9-mile by 30-mile zone about the size of Singapore. This corridor will attract a workforce of 150,000.

The Cyberjaya ("Cybercity") development company, Cyberview *Sdn. Bhd.*, is a joint venture of five Malaysian parties and Japan's Nippon Telegraph and Telephone Corp. On May 17, 1997, phase one was initiated with a $1.6 billion investment in construction of the 6,900-acre Malaysian Multimedia University. The electronic backbone of MSC will be a 2.5–10 gigabyte digital fiberoptic network that will link the corridor to Japan, Europe, and the United States.[16] Multimedia experiments planned for Cyberjaya include the use of multipurpose integrated chip cards to serve as passports, identity cards, credit cards, and electronic money for such electronic administrative needs as the provision of driver's licenses. Some delays in the Cyberjaya project are expected as a result of Southeast Asia's current fiscal difficulties.

By creating an advanced information network, Malaysia's government hopes to lure leading R&D companies and software developers from abroad. More than 900 companies have applied to participate in the MSC program. Qualifying firms must be suppliers of multimedia and other information technology products or services and be willing to transfer technology to Malaysia. Nonmanual workers such as engineers should account for at least 15 percent of the workforce. Companies that joined the project by the end of 1997 will be exempted from corporate taxes for up to 10 years.

Forty-two foreign and local companies have met MSC qualifications to locate operations in Cyberjaya, including AT&T, Sun Microsystems, and NCR from the United States; Germany's Siemens; British Telecommunications; and

[16] Syed Azman, Malaysia to launch futuristic "cybercity." http://www.merc.com/stories/egi/story.egi?id=2960936-c73

Japan's NTT, Fujitsu, NEC, Mitsubishi, Sumitomo, and Sharp corporations. NTT has already set up a subsidiary in Malaysia to benefit from the preferential treatment, including exemption from corporate tax and from mandatory rules on hiring local employees.

Singapore: Cluster Industries/Electronics

Singapore's 1991 Strategic Plan initially targeted 12 industries for development and support (aerospace has since been added):

- **Commodity trading** and **shipping** to strengthen Singapore's position as a leading international trading hub and regional headquarters for shipping and ship management activities.

- **Precision engineering, electronics**, and **information technology** to establish Singapore as the premier designer, marketer, and manufacturer of high-end precision components and systems, and high-value-added electronic products / components and as an R&D and product development center, and to support the export of software products and services.

- **Petroleum and petrochemicals, construction**, and **heavy engineering** to develop Singapore into a world-scale integrated petroleum and petrochemical hub, center for construction services for the Asia-Pacific region, and center for ship repair, oil rig construction, and manufacturing and servicing of oil and gas field equipment.

- **Finance, insurance,** and **general supporting industries** to establish Singapore as a major international financial center, regional insurance and reinsurance center, and a one-stop regional center for products and supporting services.

- **Tourism** to establish Singapore as a premier visitor destination with convention / exhibition and travel / tourism-related services.

Singapore's Economic 2000 plan stresses working relationships among government, industry, and academia to support its strategy. Singapore's infrastructure goals include maintaining the employment and GDP contributions from manufacturing at 20 percent and 25 percent, respectively.

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To support Singapore's continuing economic growth, the government is offering tax incentives for pioneering investments.

The key to this goal is its electronics industry cluster, including semiconductors, communications, display, and data storage businesses. Singapore's successful electronics development strategy produced revenues of over $45 billion in 1995. The electronics industry accounted for 51.4 percent of the manufacturing sector's output and employed 34.2 percent of the manufacturing workforce. In 1995, data storage devices were the electronic industry's most successful business, accounting for 23.3 percent of its total electronic industry output, followed by semiconductors with 21 percent. Final systems fabrication of computers and multimedia products accounted for 19.7 percent; consumer electronics, 12.4 percent; communications products, 6.3 percent; and office automation products, 5.8 percent.[17] These successes pave the way for continued development in these areas.

Singapore is using a semiconductor strategy similar to Taiwan's, with balanced development of design, fabrication, assembly, and test processes. Singapore's semiconductor industry cluster includes 23 IC design companies, 5 wafer fabs, and 19 assemble and test companies. EDB plans for 20 wafer fabs to be operating by 2005 and intends to attract 2 or 3 more companies as joint venture partners. It has also targeted microprocessors and flat panel displays as key components.

To support Singapore's continuing economic growth, the government is offering tax incentives for pioneering investments, incentives for skills training and R&D training, and special reduced taxation for specific industries and technologies. Singapore also has introduced a value-added tax system to reduce overall taxation on individuals as well as on corporations. Singapore does not tax capital gains or Singaporeans living overseas.

Singapore's 1991–1996 five-year plan budgeted over $3 billion to support new initiatives and projects. One EDB initiative seeks to upgrade Singapore from a manufacturing center to an innovation hub capable of creating new and better products and services for the region and the world. A $500 million innovation scheme grants up to 70 percent of project costs to promote innovation within companies. A second initiative ensures that worker skills are available and land requirements are met and that first-rate infrastructures will be attractive to international investors. In 1995, EDB's skills-training programs targeted emerging industries and wafer fabrication initiatives.

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[17] *Electronics Industry in Singapore* (Singapore: Economic Development Board, August 1996), p. 3.

In a separate undertaking, Singapore is building a multitechnology, ultramodern telecommunications and information infrastructure. It plans to make its port the most automated in the world. Its Tradenet system now links government agencies by computer networks that can process over 10,000 customs declarations daily. The system can handle complete documentation for trade, government administrations, transportation, banking, and insurance.

China has established supporting technological modernization as a major goal.

China: A Determined Example of Asia's Ongoing Development Strategies[18]

A nation without good scientific and cultural quality will be unable to get a foothold in world competition.

—President Jiang Zemin

National Planning for Economic Modernization

Under its ninth five-year plan (FYP) for 1996–2000, China has established supporting technological modernization as a major goal. Scientific and technological objectives include the development of rural industries, improvement of traditional industries and basic infrastructures, strengthening of export competitiveness, development of advanced technologies, support for new industries, product development, and development of technical and support services. The top three priorities are to encourage technology advancement in agricultural industries, develop a national information infrastructure, and improve factory automation processes.

China's national expenditure on S&T investments amounted to $10.6 billion in 1995, a third of which came from the government. In its new national economic plan, China's goal is to increase the percentage of GDP invested in research and development from 0.5 percent (about $2.6 billion in 1995) to 1.5 percent by 2000.

In today's China, spreading scientific knowledge is considered a "social systems engineering project" of profound and far-reaching significance. Science, technology, and education are considered the primary forces that will make the country prosperous. Part of the State's role will be to strengthen the training of high-caliber industrial workers in scientific knowledge. S&T advances combined with improved worker quality are considered essential for social development via raising national competitiveness and improving citizens' living standards.

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[18] The authors are indebted to the Commerce Department's Office of Technology Policy for reviewing the information in this section.

Technology Advancement Programs

Carefully husbanding its resources, China has borrowed program elements from around the globe to help it achieve its economic development goals. Seven national R&D programs have been established to more effectively transform research into industrial production through various stages of innovation and development. The Ministry of Science and Technology coordinates implementation of these programs.

1. The **Key Technologies Research and Development Program** targets R&D in the areas of information technology, manufacturing automation, advanced materials, space technology, laser technology, energy technology, and biotechnology. Twenty-four key technologies and one hundred twenty-four specific technology items have been selected for development within national laboratories and engineering research centers, to be integrated with other ninth FYP projects to address identified problem areas in the national economy.

2. The **National Basic Research Priorities Program** promotes development of education, laboratories, and equipment to support math, physics, chemistry, mechanics, astronomy, geology, and biology. The program includes a component of international cooperation and technology exchange.

3. The **863 Program** or **Advanced Research Program** was enacted in 1987 to benchmark world technology developments and identify and pursue indigenous innovation capabilities in the seven priority development areas mentioned in point 1 above, specifically to serve the country's economic development goals.

4. The **Torch Program**, initiated in 1988, provides incentives for renovating traditional industries, training scientists, commercializing key technologies developed in the 863 Program projects, and promoting international partnerships to commercialize Chinese research. A core concept in this program is the establishment of high-technology industrial zones (HTDZs), so-called "Torch Zones."

5. The **Spark Program** was established in 1986 to facilitate rural industrialization, including raising the technical skills and management level of village and township enterprises, helping rural industries to develop by relying on advances in science

and technology, and raising the educational level of workers. The Spark Program diffuses agricultural technologies to farmers through loans, information dissemination, and training programs.

6. The **National Science and Technology Diffusion Program** targets agriculture and related economic development. The Technology Diffusion Program was initiated in 1990 to ensure that advanced, appropriate, and mature S&T achievements are used throughout the nation's economy, especially in rural areas.

7. The **Trial Production and Appraisal Program** links science and technology with the economy through new product development and production. Trial production of new products and the appraisal of advanced technologies are typically located in HTDZs. New products are classified as state level or regional level. New products developed and produced nationwide for the first time are state-level products. New products developed and produced for the first time within a province, an autonomous region, or a municipality are regional-level products. The National Tax Bureau identifies a list of new state-level products whose taxes are reduced or remitted.

In October 1996, the "Law on Promoting the Transformation of Science and Technology Achievements" was enacted to facilitate technology activities.

In October 1996, the "Law on Promoting the Transformation of Science and Technology Achievements" was enacted to facilitate technology activities. The law creates a system for the government to manage domestic technology commercialization, protect foreign and domestic intellectual property rights, provide royalties to researchers for inventions, protect trade secrets, and support technology-based transactions.

Economic and Technology Development Zones

China's first HTDZ was developed in 1988, the year the Torch Program was instituted, to integrate research institutions with start-up incubator facilities and local and international firms that are committed to commercializing China's high-tech R&D achievements. There are now 53 Torch Zones. According to information from the Torch Program as of November 1997, some 13,000 tenant companies were located within the HTDZs, which had conducted over 10,000 Torch projects since 1991, about one-third funded by the central government, more than two-thirds funded by local governments. Revenue derived from the HTDZs from 1991 to 1997 was $10.7 billion (89 billion yuan), including $1.2 billion in exports.

In addition, China has a number of special economic zones and free trade zones spanning China's coastal cities and industrial centers that allow for duty-free imports of materials and components used to produce goods for export.

China uses its various types of development zones to deliver state incentives for commercialization of high-technology projects, whether by domestic or foreign companies (although foreign ones must generally have domestic partners). The zones encourage research institutes, colleges, universities, and start-up firms, among others, to set up new high-tech enterprises and industries. Over 40 high-tech pioneering service centers have been established in the zones to generate new projects.

As an example, Shanghai's Caohejing Hi-Tech Park specializes in microelectronics, bioengineering, new materials, automation meters, aviation, and space technology. It has more than 500 companies, of which 150 are funded by such major multinationals as AT&T, GE, 3M, ICI, Philips, Toshiba, and DuPont.

The government plans to encourage enterprises from the Shandong, Guangdong, and Jiangsu provinces to invest in 20 new industrial zones to be built inland over the next five years. Township enterprises from coastal provinces have already invested about $3.6 billion in land. The plan is expected to create five million new jobs.

Developing State Enterprises into Global Players

Growing foreign competition is putting pressure on China's state-owned enterprises (SOEs), which employ between 20 and 40 million workers. In 1996, SOE sales grew only about 3 percent. World Bank statistics report that 50 percent of SOEs lost money in 1996 and that debt ratios have reached 80 percent to 90 percent of assets. Only 5 percent of China's SOEs had been made into stockholding corporations.

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The Chinese government wants SOEs to go public to raise capital for expansion, but the SOEs must be reformed before they are desirable investments for public investors. SOEs must improve management practices, acquire advanced technologies where appropriate, train employees in information technologies, and commercialize research. The government is attempting to reform the largest 1,000 SOEs, representing 2.8 percent of SOE employees, 63 percent of SOE assets, and 70 percent of

SOE sales. Chinese officials estimate it will cost 500 billion yuan (about $60 billion) to reform the SOEs during the next five years.[19] In 1996, 300 Chinese firms were targeted to go global, becoming joint-stock companies with improved technological capabilities.

Upgrading Infrastructures

Besides these various approaches to upgrading technology levels throughout its economy, China's leadership is also working hard to improve the country's infrastructure. Though it has some ambitious and far-reaching goals, even the basic improvements will be costly. The World Bank has estimated that China will need $500 billion for infrastructure developments between 1995 and 2000. The World Bank's 1997 loan figures showed that China was once again its top recipient of loans in fiscal year 1997, receiving $2.8 billion to carry out its development strategy targeting poverty reduction, environmental protection, and job-creating growth. Since China joined the World Bank in 1981, it has received a total of $28.12 billion in loans.

The Chinese government has identified 44 infrastructure and basic material industry projects. Loans for major infrastructure projects such as those involving electricity and transportation usually come from international sources. In the first half of 1996, China raised $8.8 billion in foreign loans. Between June and October, it raised nearly $5 billion more in foreign-currency loans and bond offerings. The China International Trust and Investment Corporation, a quasi-government investment arm of the State Council, raised another $100 million in two syndicated loans and $360 million in yen-denominated bonds from Japan. The Ministry of Finance issued a global bond to raise $1 billion.

The Japan Export-Import Bank has approved billions in loans to China for infrastructure projects.

The Japan Export-Import Bank has approved billions in loans to China for infrastructure projects. Japan's Overseas Economic Cooperation Fund proposed its fourth three-year, yen-denominated loan package of $5.1 billion in 1996. The loans will finance projects implemented in the second and third years of China's ninth FYP. Japan's Export-Import Bank has provided a $1.925 billion economic development loan for construction of a thermoelectric power plant in Zhuhai. One $200 million fixed-rate bond issue by Morgan Stanley of the United States, for a highway in Guangdong Province, will be redeemed through toll payments. All of this is still a long way from the infrastructure outlays that the World Bank estimates are needed.

[19] State Statistics Bureau, *Jinrong* (Finance Journal) (Apr. 20, 1996).

China's "Golden" Projects for IT

One of China's most far-reaching infrastructure development goals is building a state-of-the-art telecommunications and information system. The core of this program consists of three so-called "Golden" Projects established in the early 1990s for completion by 2003:

1. The **Golden Bridge** project is designed to modernize the information infrastructure by developing an economic information and data communications network spanning 500 cities and 12,000 large enterprises. The project will include satellite and optical fiber cable networks for these sectors: finance, customs, foreign trade, tourism, interorganizational communications, transportation, state security, and S & T. The goal is to transmit data, documents, human voice, and pictures across the network.

2. The **Golden Customs** project will track quota permits, foreign currency transactions, and import and export statistics. It will link all foreign trade departments and support paperless trading.

3. The **Golden Card** project will replace cash transactions with an electronic service system for savings, withdrawals, and payment through credit and debit cards. By 1997, the China Electronic Information Industry Group had tested operations in 12 cities, had issued 30 million cards, and was testing advanced smart cards.

The development of China's information superhighway requires coordination among more than 20 government ministries and countless other organizations. The production and marketing information system is expected to link 360,000 state-owned enterprises and 8.6 million other firms with government offices via networks that will improve utilization of personnel, capital, and natural resources.

The development of China's information superhighway requires coordination among more than 20 government ministries and countless other organizations.

In 1995, a smart card was developed that combined the functions of a credit card, automated teller machine bank card, and telephone credit card. It was issued jointly by Visa International, the People's Construction Bank of China, and the Nanjing Posts and Telecommunications Bureau. GPT Company of Britain won a contract in May 1996 to install 500 smart card telephones in Zhejiang Province, and has signed contracts for 2,000 more smart card pay phones each for the Beijing and Guangdong telephone authorities.

Authorities forecast that 200 million smart cards will be issued over the next seven years.

Authorities forecast that 200 million smart cards will be issued over the next seven years. Card production systems are already in place. Meinen, Zeigel & Company of Germany installed 15 manufacturing systems in China and Asia in 1995 with the capacity to produce 100 million cards annually. Gemphlus Card International of France is setting up plants in China, and France's Schlumberger Smart Systems is developing applications for China in cooperation with the China Hua Xu Golden Card Company, a subsidiary of the Ministry of the Electronics Industry (MEI). IBM has established a joint venture with MEI's China Great Wall Computer Group and Kaifa Technology (Hong Kong), Ltd., to develop, assemble, and test smart cards in Shenzhen Science and Industry Park. Tandem Computer, Inc., of the United States was chosen in 1995 to provide hardware platforms for the Golden Card project. An optical memory smart card is to contain personal health care data by 2002. These Golden Projects are expected to overcome many compatibility problems as the information infrastructure is modernized.

Other Chinese ministries have begun additional Golden Projects. The Ministry of Health and Jitong Corporation are creating a network to connect large hospitals and research institutions, facilitating transmission of critical medical information and images. The Ministry of Construction will develop a network to track real estate transactions. The Ministry of Finance, the People's Bank of China, the State Tax Administration, and MEI will spend over $1.2 billion to computerize the tax collection system with the installation of 85,000 computers in 30,000 tax agencies across the nation. Companies participating in the project include AT&T, Compaq Computer Corp., Hewlett-Packard Co., Hitachi Ltd., IBM Corporation, Intel Corporation, MasterCard International, Motorola Inc., Toshiba Corporation, and Visa International.

Strengths and Weaknesses of Asia's Developing Economies

The development examples described above illustrate some of Asia's strategies to rapidly modernize and industrialize its economies, with some of their successes and difficulties. Despite the variations in the development schemes of the individual nations, there are several common themes. In general, industrial development in Asia seems to have been most rapid and most successful when conceived as a long-term effort that requires active governmental involvement to define goals and optimize limited resources, attract industry, encourage continuous technological progress through its various stages, and develop global competitiveness.

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Despite the stunning economic and technological gains achieved in the past quarter-century by the Asian countries described above, the recent downturn in 1997–98 exposed serious weaknesses in infrastructures and financial systems, as well as overcapacity in industries such as electronics and petrochemicals. Table 10 lists some of the general obstacles to continued development. Table 11 summarizes specific strengths and weaknesses of the NIEs as they relate to continued growth potential.

Table 10. Asia's Obstacles to Continuing Growth

Overcapacity: The region is overbuilding in such manufacturing areas as autos, semiconductors, consumer electronics, and chemical processing.

Weak Capital Markets: Capital is channeled too often to state-owned companies or private conglomerates. Small businesses are starved for funds.

Rising Costs: Tight labor markets are pushing up wages, while rising affluence is increasing demand for goods and housing.

Poor Infrastructure: Asia needs better highways, pollution control, port facilities, and power plants.

Widespread Corruption: It hampers small businesses and scares off some foreign investors.

Inadequate Training: Some countries have poor elementary schools, while others cannot teach workers to act innovatively.

Source: Adapted from "Time for a Reality Check in Asia," *Business Week* (Dec. 2, 1996), p. 59.

A number of uncertainties face the countries of Asia as their economies mature.

Mature and Newly Industrializing Asian Economies

A number of uncertainties face the countries of Asia as their economies mature. Japan, the dominant player in Asia and the most advanced, is struggling to solve problems in its real estate markets, financial institutions, and social security and health care systems for its aging population. Japan's ongoing economic woes despite its hard-won business and technical strengths caution Western and Asian observers to seek a balanced view of Asian economic growth policies.

The major strengths and weaknesses of Asia's NIEs can be summarized as follows.

Korea

Korea's *chaebols* are the strongest global players among Asia's NIEs. They have benefited from 25 years of government support and protected markets and are now recognized as major global players. Samsung leads in computer memory products and will expand its semiconductor capabilities. Other *chaebols* also are performing well in international markets, despite the country's fiscal woes. Korean industry is becoming increasingly autonomous as it moves abroad. Nurturing the growth of smaller companies has had some limited success. An outstanding educational infrastructure and hard-working citizens figure prominently among Korea's competitive advantages.

On the other hand, Korea faced declining exports and increased labor problems during the downturn. At the same time, it is paying the political price for its heavily regulated, highly politicized, and, by Western standards, corrupt banking system. Korea's currency and financial crisis resulted in loans worth $55 billion, including $21 billion from the International Monetary Fund (IMF), $10 billion from Japan, and $5 billion from the United States. Many financial companies closed operations. In addition, both security and economic threats from North Korea figure into the equation.

Korea's *chaebols* need to restructure and become more focused to meet the growing strength of global competition. Korea's 12th-ranked *chaebol*, the Halla group, filed for bankruptcy on December 6, 1997, with $5.3 billion in debt, 20 times the group's equity. Hyundai had guaranteed as much as $1 billion of Halla's debts. Daewoo faces financial problems in 1999. By law, the 30 largest *chaebols* are now required to lower their debt-payment guarantees to 100 percent of their equity.

Table 11. Future Growth Prospects of Asia's NIEs

Country	Strengths	Weaknesses
Korea	Giant business groups have the capital, critical mass, and engineering to compete globally in semi conductors, petrochemicals, and cars.	Fixation of big groups on commodity products hinders competitiveness in such fast-changing markets as computers and software. Costs are soaring.
Taiwan	Superior engineering and managerial talent and nimble manufacturers will preserve its edge in computer, telecom, and multimedia equipment.	High costs, traffic congestion, restriction on expatriates, and lack of direct trade with China will make it difficult for Taipei to emerge as a regional hub for multinationals.
China	Will continue to dominate light and medium-tech industries because of its enormous domestic market, pool of engineering talent, and ability to keep manufacturing wages low by tapping workers from the impoverished hinterland.	Until they are reformed and privatized, state enterprises will hobble competitiveness in heavy industries and high tech. Many entrepreneurs may have difficulties without easier access to capital. Beijing's policies make it hard for non-Chinese companies to make money.
Hong Kong	Will continue to thrive as the trading, financing, and management center of Greater China because of open business climate, skilled workforce, and top-rate infrastructure.	High real estate prices could hamper growth. Negligible R&D makes manufacturing vulnerable. Handover to China could weaken legal system and dull edge as media center.
Singapore	Will remain a prime multinational hub because of first-rate facilities, training institutes, skilled workforce, and lack of corruption. Big government subsidies in science give it an edge in research and development.	High costs and small domestic market could curb expansion. Few indigenous manufacturers are successful overseas. Social controls, rote education, and limits on media hamper drive to nurture entertainment and design industries.
Malaysia	Should continue as Southeast Asia's favored manufacturing and design hub for multinationals because of highly skilled workforce and attentive government.	Costs are rising twice as fast as productivity. Shortages of production workers and engineers are developing. Few globally competitive domestic manufacturers are emerging.

Source: Adapted from "Time for a Reality Check in Asia," *Business Week,* (Dec. 2, 1996), p. 59.

Taiwan has successfully established a global position in electronics products and key components.

Taiwan

Taiwan has successfully established a global position in electronics products and key components and has a significant number of firms capable of taking their operations into the global market. Taiwanese firms' original development strategy has made them leaders in new product introductions. The country's key component and product strategy ensures that adequate resources will be available for continued development of technological and product capabilities.

Taiwan's economic successes are tempered somewhat by its ambivalent political status vis à vis mainland China, both in terms of its relations with other countries (few countries want to alienate China) and in terms of the political and economic aspirations of its people. Solution of this political problem does not appear to be imminent; meanwhile, however, Taiwan continues to engineer its rapid economic growth, based in no small measure on tapping business opportunities in China. In the long term, China hopes for Taiwan to provide a key technology base for its continued development.

Singapore

Singapore appears to have developed the most comprehensive approach to attracting MNCs and keeping them involved in its economy. The government provides incentives to establish management and operational headquarters in Singapore, actively aids companies in moving factory and marketing operations across the region, and provides incentives for firms to conduct their research activities in Singapore.

Singapore is making major investments to establish the most advanced telecommunications system in Asia, while continuing to promote technology-based, value-added manufacturing. Singapore aspires to become the primary financial center for the Asia-Pacific region. Its goal is to become the "intelligent island" in the age of information technology. Some say its "economic miracle" has come from a totally managed society that critics argue is overregulated.

Malaysia

Malaysia achieved very high growth rates until the financial crisis that resulted from heavy foreign investment in high-tech manufacturing. Malaysia's vision still is to be totally developed by 2020. It plans to build the most advanced information technology infrastructure in the world. In spite of its recovering growth rate, the earlier rapid development has caused structural economic issues such as a huge current account deficit.

Malaysia is aggressively pushing to build an independent technological lead in multimedia. This follows a similar approach taken earlier in the automobile industry. By making a strong financial commitment, providing 10-year tax holidays to technological leaders, and developing next-generation infrastructure and products, Malaysia will continue to be an aggressive player in Southeast Asia.

China and Hong Kong

China's strong commitment to upgrading its technology base and infrastructure encourages foreign firms to locate operations close to its 1.2 billion-consumer market. In China today, fewer than 5 percent of the people own a dishwasher, clothes washer, vacuum cleaner, microwave oven, or car. There is one telephone for every 25 people, one fax for every 200 people, and one PC for every 400 people. High-tech industrial parks, such as the China-Singapore Suzhou Industrial Park near Shanghai, and special economic zones, such as Shenzhen, are central to China's strategy. Hong Kong provides direct access to China.

China's strong commitment to upgrading its technology base and infrastructure encourages foreign firms to locate operations close to its 1.2 billion-consumer market.

China fever abated somewhat in 1997, 1998, and 1999. For example, the total value of new pledged foreign investment contracts dropped 20 to 30 percent in 1996 and 1997. Few people can predict the long-term impact of Hong Kong's return to China. There are many questions about Hong Kong's ability to continue to provide world-class service under Chinese rule. It has become increasingly expensive to operate in Hong Kong, and the education base there has its own shortcomings. However, Hong Kong is expected to aid China's ability to upgrade its business skills and provide a key channel for raising capital.

Contrasts Between the Asian NIEs

As the statistics in table 1 showed, there are sharp contrasts among the United States, Japan, and some of Asia's newly developed economies. Singapore stands out as the country with the highest percentage of population in the workforce. While Japan has the second highest percentage of workers, its aging population is likely to cause a decline in workforce percentage. In education, Korea has the highest percentage of university graduates in the work force, but still struggles to improve the indigenous innovative capability required to develop advanced technologies. This difficulty has a negative impact on GDP growth.

The countries in Asia are rivals in pursuit of Western business, which has resulted in overcapacity of operating facilities. This situation has provided

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an opportunity for Western firms to exploit low-cost sources of supplies in Asia, especially in electronics components. Continued development by the United States of close relations with Asian countries provides continuing economic opportunities. As Henry Kissinger has noted, "We are, or could be, closer to each of the contenders in Asia than they are to one another."[20]

Table 12. Asia's Future Growth Prospects

Country	Strengths	Weaknesses
Philippines	Surplus of literate, English-speaking workers and engineers and abundance of cheap land are drawing investments in electronics and auto parts. Its open society makes it rich in the creative talent required for media and marketing.	Lack of infrastructure outside the Manila area makes much of the country unviable as a production base. Labor-intensive assembly work is threatened by low productivity. It is too weak in sciences to be a major R&D hub.
Thailand	It is Southeast Asia's most advanced production base for cars. It has strong ties with leading Japanese multinationals. Sophisticated private telecom companies and a free press could position it well for media industries.	Rising wages are driving out labor-intensive industries, while shortages of technicians and managers are developing. The political system makes it difficult to solve problems in infrastructure and education.
Indonesia	It will continue to grow in light industry because of its enormous supply of cheap labor. Abundant natural resources give it an edge in oil and timber.	Heavily protected local producers of cars and electronics are poorly positioned for freer trade. Low labor costs are offset by red tape, corruption, and poor infrastructure.

Source: Adapted from "Time for a Reality Check in Asia," *Business Week*, (Dec. 2, 1996) p. 59.

Less Developed Asian Economies

Less developed Asian countries such as the Philippines, Thailand, and Indonesia have benefited from the successes and rising wages of their more developed neighbors. These LDCs also have their own strengths and weaknesses, as summarized in table 12. They, too, are taking on the challenges of managing rapid industrialization. Those countries that are able to overcome political problems and build effective development strategies will also participate in Asia's future economic expansion. Growth in

[20] "The Folly of Bullying Beijing," LA Times, (July 6, 1997), p. M2.

regional and global demand require continued expansion of Asia's industrial base. Rising wages and full employment in the NIEs provide continued opportunities for the LDCs of Asia. For example:

- **The Philippines** has benefited from the regional expansion of firms from more developed countries. However, political unrest and official corruption continue to be problems. Corrective actions seem limited as long as the powerful landed gentry resist moves toward economic reform and discourage foreign investment. While the closing of the Subic Bay and Clark military bases chilled relations with the United States for a time, the infrastructure that remained has served the Philippines well in attracting industry and jump-starting its economic growth. However, the thriving industrial complexes now located at the bases are in serious need of expanded infrastructure.

- **Thailand** had its financial crisis because of a banking system burdened by a host of bad loans. Pressures on its currency affected the fiscal stability of such neighboring countries as Malaysia, the Philippines, and Indonesia. At the present, rising wages are making manufacturing in Thailand less competitive, and it is struggling in its effort to move up the ladder to higher-value products. It is further being constrained by an educational system in need of serious improvement.

- **Indonesia** still is in a state of political as well as economic crisis, although signs offer hope. As the people's economic and political aspirations continue to rise, Indonesia's leaders are addressing the difficult structural changes demanded by the IMF in return for a $43 billion rescue package to stabilize Indonesia's currency. The country also seriously needs an improved communication system because of its geographical structure. Its 13,500 islands stretch 3,200 miles east to west and 1,100 miles north to south.

- **Vietnam**. The addition of Vietnam to the Association of Southeast Asian Nations (ASEAN) appears to have been the most successful of the ASEAN expansion efforts to date. Vietnam is at the center of the most dynamic economic region in Asia. It is fast developing a market economy driven primarily by foreign investments exploiting its low wage rates. Vietnam is a country still debilitated by the ravages of war, with an almost nonexistent communications and transportation infrastructure. Its GDP per capita is about one-quarter that of Indonesia or the Philippines. The situation should, however, quickly improve because of major investments from Hong Kong, Taiwan, and Australia.

- **Cambodia, Laos, and Myanmar**. Although ASEAN has been a stabilizing and supportive force for areawide economic development, it has yet to have much impact on the least developed countries of the region. The concern for human rights in both Cambodia and Myanmar is politically distracting. At this time, prospects for development in these countries are limited. Myanmar may have some advantage because of its location and the completion of the China highway that will link South China to Thailand through the northeast corner of Myanmar.

1999 forecasts put most Asian economies back on the road toward rapid growth.

As shown in table 13, Indonesia and Thailand are expected to see shrinking economies in 1998 because of serious financial problems and the collapse of regional markets. However, 1999 forecasts put most Asian economies back on the road toward rapid growth. Even if the forecasts are too optimistic in the short term, many observers already see signs of recovery and restructuring in most countries that bode well for Asia's long-term economic recovery.

Table 13. Real GDP Growth in Asia (percent)

	1997 actual	1998 actual	1999 forecast	2000 forecast
China	8.8	7.8	6.6	7.0
Hong Kong	5.3	–5.1	–1.3	3.1
Taiwan	6.8	4.9	3.9	4.8
Indonesia	4.6	–13.7	–4.0	2.5
Malaysia	7.7	–6.8	0.9	2.0
Philippines	5.2	–0.5	2.0	3.0
Singapore	8.0	1.5	0.5	4.2
Thailand	–0.4	–8.0	1.0	3.0
Japan	1.4	–2.8	–1.4	0.3
Republic of Korea	5.5	–5.5	2.0	4.6
India	5.5	5.6	5.2	5.1
Australia	3.6	5.1	3.1	3.2
New Zealand	2.1	–0.3	2.7	3.3

Source: IMF, *The World Economic Outlook*, May 1999, pp. 9, 16, 17.

The Asian Model for Development

The Asian experience shows that there is no perfect set of actions that guarantees economic development without risks and setbacks. Governments must be flexible in dealing with the ever-changing competitive terrain by adjusting development strategies as conditions change and the relative strengths of competing countries grow.

The lessons that can be learned from the Asian experience are worth noting. These lessons revolve around the strategies and trends in low-cost labor, infrastructure investment, worker skills, support for technology, and the business climate. They also reflect the growing impact of globalization and regional cooperation.

Competitive Strategies and Trends

Low-Cost Labor

The search for low-cost labor continues to be the primary driver of economic development across Asia and other developing areas of the world. It dictates constant changes and updates in strategies to attract and retain investment and increase standards of living.

The search for low-cost labor continues to be the primary driver of economic development across Asia.

As development occurs and labor costs increase, there is a corresponding growth in the purchasing power of consumers for products and services that in turn creates a significant market opportunity. The growth in the purchasing power of Asia's population of 3 billion, especially its growing middle class, during the early and mid-1990s created a significant market opportunity. Domestic and foreign corporations invested in Asia in hopes of capturing an early market position.

Asian countries with rising labor costs turned to technology-led economic growth strategies as a way to continue to increase their standards of living as some types of investment inevitably began to move to lower-cost producers. Singapore has developed its own strategy to build and manage "world-class" industrial parks in Vietnam, China, Indonesia, and India to benefit from the move by helping firms expand low-cost operations across Asia.

The impact of the economic slowdown on this scenario is mixed. Labor costs in some Asian countries have fallen, increasing their attraction for some types of investment. On the other hand, the purchasing power of much of Asia's middle class is stagnant or in some cases declining, negatively affecting market opportunity.

Demand for all forms of infrastructure investments drives corporate and country strategies.

Infrastructure Investment

Demand for all forms of infrastructure investments drives corporate and country strategies and is an important part of the Asian development model. Basic industrial infrastructure is a competitive advantage in attracting business to a country. Before the economic slowdown, infrastructure investment began to allow Asian economic growth to expand from a limited number of urban areas to broader geographical areas.

As Andrew Tranzer noted in 1996, "East Asia is now capturing over 60 percent of the world's private capital flows to developing countries, an inflow worth $100 billion in fresh capital every year—not to mention managerial and technical expertise (East Asia central banks collectively hold more than $600 billion of foreign reserves)."[21]

Despite the setbacks of 1997–98, Asian countries still are investing in building the infrastructures needed by tomorrow's information societies. It is expected that the Asia-Pacific region (excluding Japan) will spend a trillion dollars on infrastructure in the next 10 years.

Singapore's IT 2000 strategy calls for the creation of a national information network with all homes, schools, businesses and government agencies interconnected in an electronic grid. China plans to spend more than $40 billion installing the equivalent of a Bell Canada–size network each year until 2000. China's government also has established its "Golden" projects to boost its communications systems, record-keeping, commercial transactions, and so on into the information age. And the Philippines is taking advantage of military bases vacated by the United States.

Where extending advanced infrastructures across an entire economy is too costly and complex to accomplish in the short term, science and technology "parks" have allowed countries to rapidly build state-of-the-art mini-economies within a geographically restricted area. Reduced tax rates, advanced infrastructure, and policies such as one-stop regulatory

[21] Andrew Tranzer, "The Pacific Century," *Forbes* (July 15, 1996), p. 108.

permitting give Asia's high-tech industrial parks an advantage in attracting or keeping global competitors.

Worker Skills

Ability to compete globally is not a function of national size, as Malaysia, Korea, Singapore, Taiwan, and Hong Kong demonstrate. There are many reasons for the success of their companies, but it is becoming increasingly obvious as their labor costs have risen that their primary competitive advantage is their growing knowledge base and number of skilled workers.

Today every country can easily tap into global technology, acquire advanced manufacturing practices, adopt the best financial techniques, acquire investment money from international venture capitalists, and employ knowledgeable workers from around the world. In today's globally competitive environment, the best jobs go where the most qualified workers are available. Conversely, advanced education in science and technology results in the highest-paying jobs and the most benefit to the economy. Countries with inadequately trained workers tend to find themselves locked into low-paying, low-value-added assembly-type jobs and industries. Lester Thurow expressed it well when he said, "The skills of the workforce are going to be the key competitive weapon in the 21st century" in *Head to Head: The Coming Economic Battle Among Japan, Europe, and America* (William Morrow & Co., 1993).

Support for Technology

Asia's success in applying advanced technology resulted in part from substantial investment and commitment to specific emerging industries and critical supporting technologies. In the early stages of development, Korean government-funded research institutes provided an important mechanism in building the research strength of its chaebols. ITRI in Taiwan has been responsible for supporting the electronics industry and entering the semiconductor industry. In Singapore, government research institutes target industries and subsidize R&D for foreign firms willing to conduct local research and build a local technology base. In addition, Singapore's EDB directly subsidizes high-tech development programs. Malaysia's "multimedia corridor" called "Cyberjaya" provides various types of support for companies locating in it, including a new multimedia university.

Development of multitechnology / multimedia products often also requires strategic alliances for more rapid and efficient development, since internal development may be too slow in getting to market in a

Asian NIEs have effectively targeted growth industries and related technologies for development.

timely fashion. Taiwan's entry into the semiconductor business has included every major player in the world.

Asian NIEs have effectively targeted growth industries and related technologies for development. Many of the targeted areas are in electronics, multimedia, and information fields. Taiwan is only one example of the practice of targeting. Its Critical Components strategy targeted 48 critical components and 24 critical products to provide global leadership in 10 emerging industries. The Taiwanese government has provided R&D, prototyping, and ramp-up incentives and support to semiconductor and LCD technologies. As a result of this kind of targeting, Taiwan, as well as the other NIEs addressed in this study, is achieving first-rate competitiveness in global electronics, multimedia, telecommunications, and information markets, successfully challenging traditional leaders. Hong Kong's Vtech has over 50 percent of the world's electronic learning aids market. Taiwan's Acer ranks among the top 10 PC companies in the world, competing directly with U.S. and Japanese leaders. In key computer components, Singapore's Aztech Technology controls nearly 90 percent of the world's sound card market. Korea's Samsung is the world leader in DRAM technology.

Business Climate

The growing ease of doing business in Asia has facilitated economic growth. Singapore's "one-stop shopping" strategy has been very attractive to MNCs. Hong Kong's high-quality services and management infrastructures provide a critical bridge for companies seeking to do business in China's industrial parks and special economic zones. Similar strategies are being used across Asia to allow efficient local administration of industrial development policies.

Offering attractive investment incentives is an important component of Asian industrial development strategies. Investment incentives offered by Asian NIEs include tax holidays, exemptions, and reductions; another factor that draws investors is improved access to new markets. In terms of sheer size of investments, China, despite large declines in the past three years, has been the Asian country most successful recently at attracting foreign investment, about a third of all manufacturing-related investments in developing nations.

Environment

Sustained and sustainable economic growth is also linked to the ability to integrate environmental and productivity decisions. A clean environment, particularly as it affects production of high-technology products, is increasingly a competitive issue in Asia.

In Beijing, NEC had to isolate and air condition its entire factory to keep pollution from affecting the quality of its IC production. Through ITRI, Taiwan is investing heavily in cleaner production research and technology.

Globalization and Cooperation

The Asian experience suggests that to improve competitiveness, local high-technology companies can and must rapidly begin to expand operations beyond the national economy, since economies of size and scale demand their involvement in as many markets as possible. Localization of business activities must then focus on marketing and distribution.

The Korean experience also indicates that as companies go global, they must intensify efforts to develop next-generation technologies. Research centers must be established not only at home but also in major technical centers abroad, as Japan and Korea have done in the United States and elsewhere.

Regional cooperation is an increasingly important element in competitive Asian development practices.

Regional cooperation is an increasingly important element in competitive Asian development practices. With eight cooperative growth triangles, superior technologies and development practices are moving rapidly throughout the Asian region. For example, the Southern China Growth Triangle unites Taiwanese technology and management skills with Hong Kong's distribution and service skills and Southern China's low-cost production expertise.

Singapore and Malaysia provide capital and leadership in the development of the Southeast Asian region through ASEAN. ASEAN is now sponsoring the Association of Indian Ocean Rim Countries and the South Asia Association for Regional Cooperation, which involves India, Bangladesh, Nepal, Sri Lanka, and Pakistan.

Project-based cooperation also exists. For example, in February 1997, a submarine optical fiber network was completed that links nine Asian nations (Japan, Korea, Taiwan, Hong Kong, the Philippines, Thailand, Malaysia, Singapore, and Indonesia)—a length of over 12,000 kilometers. The $650 million project, built by a consortium of companies from the United States, Japan, France, and Great Britain, began in 1994 as part of an effort to build an Asia-Pacific Information Infrastructure. Another area in which cooperation is evident is the financial support extended by the healthier Asian economies to those experiencing fiscal difficulties at this time.

Obstacles to Continued Growth

Despite aggressive strategies to upgrade technologies and attain global competitiveness, Asian countries face various obstacles to sustaining their economic growth:

- Overcapacity and strong price competition have resulted from heavy investment in a small range of industries including automobiles, semiconductors, consumer electronics, and chemical processing. In addition, the Asian economic slowdown has cut recent forecasts of automobile sales in 2000 by nearly half for Thailand, Indonesia, Malaysia and the Philippines.[22]

- Many local firms are ill prepared as they restructure to meet World Trade Organization membership requirements for local market access by global competitors. The IMF also is committed to opening the Asian financial system to global competition, with Japanese deregulation that began in 1998.

The scarcity of local capital makes it difficult for developing nations to build infrastructures or properly capitalize their own local firms.

- The scarcity of local capital makes it difficult for developing nations to build infrastructures or properly capitalize their own local firms. Short-term foreign loans placed countries like Thailand in serious financial jeopardy, since signs of economic slowdown cause foreign capital to exit rapidly and generate pressures for currency devaluation. Small entrepreneurial firms cannot grow without access to such funds.

- There is a shortage of talent needed for advanced stages of development. Weak school systems and a lack of creative thinking are exposed as labor costs rise and higher-level skills are needed. Simple lack of experience operating in an international milieu increases risks.

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[22] Salif Tripathi, Ben Dolven, and Prangtip Daorueng, “Asia’s Sinking Middle Class,” *Far Eastern Economic Review* (April 9, 1998), p. 14.

- As some of the experiences of Japan and Korea have demonstrated, heavy regulation and administrative guidance directed at protecting local markets can prove to be dysfunctional to industry restructuring in the face of increased global competition and rapid technological and market change.[23] Protective government regulations are difficult to dismantle, but if not dismantled can ultimately impede growth by slowing market responsiveness. As product life cycles fall from years to months, bureaucratic interventions or management delays can rapidly cause local firms to lose competitive advantage.

- Many Asian business relationships and activities (1) are illegal under the 1977 U.S. Foreign Corrupt Practices Act, (2) inhibit competition, restructuring, and rationalization of growing Asian economies, or (3) impede working relationships with potentially helpful multinational corporations and organizations such as the IMF. While seeking to stabilize the Asian economies, the IMF has a longer-term objective to reduce the incidence of political corruption. On December 17, 1997, 34 OECD nations signed an antibribery treaty that will make payments to government officials a criminal act following the U.S. Foreign Corrupt Practices Act. Such pressures to change traditional or accepted business practices can greatly stress rapidly developing economies.

Despite these obstacles, overall, Asian countries are rapidly adopting proven strategies for economic development. As more and more nations commit to developing high-tech industries, national and corporate competition is increasing in both emerging and established industries. The focus in India, China, and the Philippines on software, challenging U.S. domination of this industry, is an example of the constantly changing competitive landscape.

Most Asian countries are counting on technology development to help them grow out of their present difficulties.

While the aftermath of the financial and monetary crisis is expected to continue to slow Asia's growth rate in the next two to three years, economic expansion is not expected to stop; in fact, most Asian countries are counting on technology development to help them grow out of their present difficulties.

[23] Presentation by Chihiro Watanabe, Senior Director, R&D Programs, AIST/MITI, at Keio Business School in November 1993.

The recent stability in the U.S. economy has generated steady growth and provides full employment.

CONSIDERATIONS FOR U.S. POLICYMAKERS

The recent stability in the U.S. economy has generated steady growth and provides full employment. The breadth and depth of the U.S. technology base continues to be second to none.

Long-term competitiveness, however, relies on education, infrastructure, innovation, and initiatives that encourage both domestic operations and global leadership. As the U.S. market diminishes in relative global importance, it must sustain its innovative and technical capabilities in order to support continued economic stability and growth. Asian (and other) nations are challenging U.S. leadership in emerging high-technology industries: as Japan has successfully targeted steel, automobiles, and semiconductors, Taiwan has successfully targeted computer-related technologies, and Malaysia is targeting multimedia technologies. Such challenges cannot be overlooked. As nations compete for leadership in advanced technologies, the United States must ensure that its "crown jewels" are not lost to foreign competition.[24]

Therefore, it is essential for the United States as well as less developed countries aspiring to higher standards of living to be mindful of the lessons of the Asian model of development. Asian global strategies are addressing five fields that all countries should consider crucial to success in high-technology industries:

1. Educating and effectively utilizing knowledge workers, creating new knowledge, and protecting related intellectual property.

2. Increasing their access to global markets to ensure competitive economies of scale and recognition of evolving product and market standards.

3. Developing advanced infrastructures to attract and support global technology leaders and to facilitate development of local firms that can compete in the global marketplace.

4. Attracting and investing the capital needed to build essential infrastructures and to develop technologies and capacity for emerging growth industries.

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[24] Jung Wha Han and William R. Boulton, "Strategic Responses of U.S. Firms to the Japanese Competitive Challenge." *Advances in Applied Business Strategy*, Vol. 3. (Greenwich, CT: JAI Press, 1992), pp. 69–90.

5. Using legislative and fiscal incentives to induce high-technology companies to locate and participate in local R&D and value-added operations.

There also are market opportunities to consider. Since many countries lack the technology base needed to enter emerging businesses by themselves, strategic alliances offer U.S. firms opportunities to participate in the establishment of future industries in many locales. Careful management of international market alliances will be imperative to future U.S. economic success, as will open markets, rapid responses to market and technological change, and continued cost competitiveness. Like Japan, the Asian newly industrializing economies' growing technological base offers a source of a new and unique R&D.

While the United States finds itself in a comfortable economic position today, it can expect growth in global competition supported by aggressive industrial development strategies from newly industrializing countries in Asia and elsewhere. The new competitive paradigm will demand continued infrastructure and technology development, global market access, and creative new responses to both competitive and cooperative challenges from the Asian countries of the Pacific Rim.

The new competitive paradigm will demand continued infrastructure and technology development.